THE
BRITISH JOURNAL OF SURGERY

VOL. XXIV OCTOBER, 1936 No. 94

IPSISSIMA VERBA

BY SIR D'ARCY POWER, K.B.E., LONDON

XI. TWO LIVERPOOL SURGEONS

I. HENRY PARK, WHO EXCISED JOINTS IN 1781

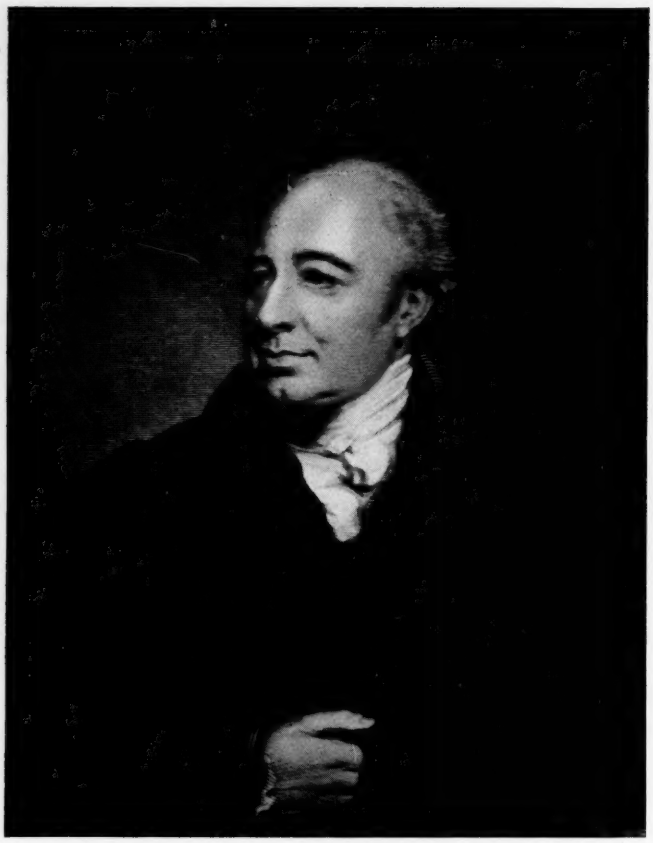
HENRY PARK, surgeon to the Liverpool Hospital, was amongst the first to recommend excision of joints when amputation was the routine method of treatment, and his work is therefore well worthy of remembrance. For the facts of his life as well as for his portrait I am indebted to Mr. Raymond Tinné Berthon, his great-grandson.

Henry Park was born in Water Street, Liverpool, on March 2, 1744–5, the son of Edward Park, apothecary, and Mary, daughter of John Lyon, mariner, of the same town. He was apprenticed first to James Blomfield, surgeon to the Liverpool Infirmary, his uncle by marriage; afterwards to Percivale Pott, with whose family he maintained so close a connection that Edward Holden, Pott's second son, is said to have been buried in Park's family grave at St. James's, Toxteth Park, Liverpool. This Edward Holden Pott is described as "late Major of the Royal Westminster Militia who died September 1st, 1798, aged 32 years."

Pott's influence on Park is shown by the pamphlet published in 1783 with the title, "An account of a new method of treating Diseases of the Joints of the knee and elbow in a letter to Mr. Percival Pott." In this letter he describes a case of excision of the knee for advanced tuberculous disease in the following words. "I had under my care in the Infirmary Hector M'Caghen, a strong, robust Scotch sailor, aged thirty-three, who was admitted for a diseased knee of ten years standing, the joint, though pretty considerably enlarged, was by no means so much so as is frequently met with in scrophulous affections; yet the integuments were so tense as to appear incapable of yielding to further distension; the contraction of the Flexor muscles was such as to draw back the leg, so as to form a right angle with the thigh, in which position it was immoveably fixed; apparently some degree of union with the bones had begun to take place, but this could not yet be determined with certainty, as every attempt to communicate to the joint the smallest degree of motion gave him the most excruciating pain. This poor man's sufferings were daily increasing and his health daily declining, in such a degree, that he began to beg to have the limb taken off. This, however, I could not consent to do, without first proposing

and explaining to him the extirpation of the joint, in order that he might have the chance of such a cure, if he chose to take it. He assented without much hesitation and the operation was accordingly done on the 2nd July, 1781."

Park had previously performed excision of the knee and elbow on dead bodies, using a longitudinal incision and removing the patella. He found, however, that he " had not made sufficient allowance for the difference between a healthy and a diseased state of the parts ; in short, there appeared so much confusion of parts on opening the articulation, the ligaments being in some parts extremely thickened and



HENRY PARK

horny, in others in a sloughy suppurated state with the cartilages almost wholly destroyed and the heads of the bone much eroded by the offensive matter of which there was a good deal in the joint ; besides that some degree of bony union had begun to take place between the head of the tibia and the inner condyle of the Femur that, after spending some time in the attempt and consequently making the operation much more painful and tedious it was thought advisable to relinquish this idea and to make a transverse incision and divide the femur above the condyles.

" The quantity of bone removed was somewhat, though not much, more than two inches of the femur, and of the tibia rather more than one inch which were but

just enough to enable me to bring the leg into a right line with the thigh. The only artery that was divided in the operation was one on the anterior part of the knee which ceased to bleed before the operation was concluded though the pulsation continued pretty strong in the ankle; the ends of the bone, however, particularly that of the femur bled pretty freely. A few stitches were passed through the skin, as well along the course of the Transverse incision as of that part of the longitudinal one that extended up the thigh. The lightest superficial dressings only were applied and the limb placed in a case of tin sufficiently long to receive the whole of it, from the ankle to the insertion of the glutæus muscle".

The man passed the day in a good deal of pain; had frequent vomitings and lost a good deal of blood". He did well eventually, and "on the seventh day the cavity was lightly filled with dry lint, and a turnip poultice was laid over it because I find in general that the turnip poultice is less uneasy than one of carrots and is remarkably speedy and powerful in correcting the fœtor of putrid ulcers and therefore particularly valuable in an hospital." The patient was discharged with three inches of shortening in June, 1782, eleven months after the operation. He was reported later to have gone back to sea, having "laid aside his crutch, and gotten a strong and useful limb free from pain or swelling."

Park concludes his letter modestly, saying: "I beg that I may not be so far misunderstood as to have it supposed that the method I have been recommending will certainly succeed in every case. I know the contrary and fear that after the Chirurgic art has done all that it is capable of, many of these diseases will still occur in which Amputation only can preserve the life of the patient. I am conscious that the mode of operating which I have described is by no means perfect but still stands in need of the finishing hand of a more able master."

For the rest Park married on May 1, 1776, Elizabeth, the eldest daughter of John Ranicar, of West Leigh, Lancashire, and by her had two sons and seven daughters. He was appointed surgeon to the Liverpool Infirmary in 1767, resigned in 1790, continued to practise until 1815, and died at Wavertree on Jan. 22, 1831. From 1769 to 1830 he kept a Register of the midwifery cases he attended, and amongst the 4000 patients perhaps the most momentous was that on "29th December, 1809. A. Gladstone at Rodney St." She was Anne, daughter of Andrew Robertson, Provost of Dingwall, and the second wife of Sir John Gladstone. The boy was (The Right Honourable) William Ewart Gladstone.

The portrait is from the engraving of a drawing made in 1832 by T. Hargraves and engraved by George T. Doo, kindly lent by Mr. Raymond Tinné Berthon.

THREE CASES OF GLOMANGIOMA OR ANGIONEUROMYOMA
(PAINFUL SUBCUTANEOUS TUBERCLE)

By W. ARTHUR MACKEY
ASSISTANT TO THE PROFESSOR OF SURGERY, UNIVERSITY OF GLASGOW
DISPENSARY SURGEON, WESTERN INFIRMARY, GLASGOW

AND ALAN C. LENDRUM
ASSISTANT TO THE PROFESSOR OF PATHOLOGY, UNIVERSITY OF GLASGOW
ASSISTANT PATHOLOGIST, WESTERN INFIRMARY, GLASGOW

THE name glomangioma has been suggested by Bailey[1] to describe the simple tumour of the neuro-myo-arterial glomus. This rare neoplasm arising from the specialized arteriovenous anastomoses of the skin appears to be a well-defined pathological entity, for not only has it a highly characteristic histological appearance, but in most of the recorded cases it has caused symptoms which are striking and apparently pathognomonic. In fact, as Greig[2] points out, the symptomatology is so definite that retrospective diagnosis is justifiable and so allows the grouping of cases which have gone under very different names. This nomenclature, varying from 'angiosarcoma' of the German writers to 'painful subcutaneous tubercle' of the English (Wood, 1812, quoted by Greig), is a reminder of the insecure pathology of earlier days. It is probable that some of the so-called peritheliomata have been neoplasms of this type.

The first systematic investigation of the histology and histogenesis of these tumours was carried out by Masson,[3] and other workers have confirmed the value of his findings. As a result of his work, interest has been renewed in the structure and function of the normal glomus (Popoff[4]). This is now known to be a much convoluted, modified arteriole communicating directly with a vein. It possesses a characteristic cellular wall, with a rich perivascular nervous network; dilatation and constriction are thought to occur independent of the state of the parent vessel. The narrow channel with its thick coat of cuboidal cells has been called the Sucquet-Hoyer canal. The glomera are most common in the extremities, especially in the nail-beds. The glomus coccygeum, for whose site it is difficult to find a reason, is structurally similar, and presumably serves a comparable purpose. The cutaneous glomus is believed to act as a type of shunt, and to exercise some as yet incompletely understood function in the maintenance of the circulation in peripheral parts exposed to cold, and in the regulation of temperature (Grant and Bland[5]).

Recent references to these tumours are almost entirely American, including a brief annotation by Love,[6] and reviews by Raisman and Mayer,[7] Lewis and Geschickter,[8] Stout,[9] and Bailey[1] with addition of new cases. In presenting our cases we would refer the reader to these reviews for fuller discussion. The first of the tumours to be described by us was removed by one of us (W.A.M.) in Glasgow. The other two occurred in Australia, and we are very grateful to Dr. Keith Inglis, Lecturer in Pathology, University of Sydney, for histological preparations and clinical notes, and for his permission to publish the cases.

CASE HISTORIES

Case 1.—The patient (M.R. 162/1936), a labourer, 24 years of age, was referred to the Out-patient Department of the Western Infirmary, Glasgow, for treatment of what was believed to be a localized collection of varicose veins on the middle of the front of the left shin. This had been present, to his knowledge, for fourteen years, for the most part without inconvenience. For the last two years, however, he had had increasing pain, which finally led him to consult his doctor. This pain, which he described as a feeling of stiffness and soreness, was situated in the lesion, and radiated laterally to the calf and up and down the front of the leg, and to the knee. It was aggravated by exercise, especially when, at his work, he carried heavy loads. Occasionally pressure over the site caused pain to shoot up the front of the thigh. The lesion appeared to be more sensitive to heat than to cold, and latterly his sleep had thus been much upset. He noted that when painful the lesion became congested, swollen, and dark in colour. There was no history of trauma.

Examination revealed a mulberry-like mass with a coarsely nodular surface, bluish in colour as if engorged with blood; it was 1½ in. in vertical length by 1 in. in breadth. The patient made no complaint of tenderness when it was examined. The first impression was of a localized varicosity, but the absence of change in the remainder of the saphenous system, the long history, and the very slow growth led to a diagnosis of venous angioma.

So thin was the overlying skin that some sacrifice of this at operation seemed probable. Under local anæsthesia, a short transverse flap was therefore raised; the lesion was then seen lying almost free, like a bunch of small grapes, in a pocket in the subcutaneous fat. It was dissected out with ease, and found to be united, not to a vein, but merely to a thin, fairly firm pedicle, which was clamped and ligated. It seems probable that this included the afferent vessel of the tumour.

Case 2.—(S.H. 74/1920.) A man of 59 years, under treatment for epithelioma of the lower lip, showed on the medial aspect of one elbow a pedunculated soft blue mass, which was removed for examination. It is not recorded whether the lesion was painful.

Case 3.—(S.H. 16001/1936.) A boy of 12 years presented a painless swelling on the lateral aspect of the knee, considered to be the result of a blow with a cricket ball seven years before. At operation, an unencapsulated tumour of fatty vascular appearance was found, lying antero-lateral to the tendon of the biceps femoris. It was unattached to skin, or to any of the deeper structures.

HISTOLOGICAL APPEARANCES

Case 1.—The tumour is a roughly circumscribed angioma, with a well-developed stroma and slight condensation of the surrounding tissue. The most distinctive histological feature is the presence, in definite relation to the blood spaces, of large numbers of cuboidal cells. These cells, separated from the endothelium by a basement membrane of varying thickness, are typical glomus cells, as seen in the Sucquet-Hoyer canal of the normal glomus, roughly cuboidal, showing a circular nucleus and a clear and mostly structureless cytoplasm. There is a distinct collagenous limiting membrane round each cell (*Fig.* 172).

The general architecture of the tumour (*Fig.* 173) shows a zonal arrangement, which may be correlated for purposes of description with the distribution of the glomus cells. *In the peripheral zone*, the vessels are of relatively small calibre and appear to be but slightly convoluted; they show a uniform tubular coat of several layers of glomus cells, lying directly under the endothelium. The vessels lie in a fatty areolar connective tissue, occasionally forming a leash, and giving the appearance of a cellular mass traversed by vascular spaces (*Fig.* 174). In one of the vessels in this zone a few muscle fibres are seen between the endothelium and the glomus cells; this conforms to Masson's 'first type vessel', which he presumes to be afferent to the tumour. *Toward the centre* of the growth the arrangement becomes more cavernous, with irregular blood spaces lined by endothelium, which is separated from the supporting fibrous framework by only two or three layers of glomus cells. *In the central parts of the tumour* the stroma shows thickening into nodules of fibromyomatous nature with some myxomatous degeneration. The intervening vascular clefts show a prominent

endothelium but no definitely related glomus cells, although collections of these are scattered throughout the fibromyomatous tissue. Many are morphologically identical with the glomus cells in the rest of the tumour, but all forms of transition are seen between the glomus cells

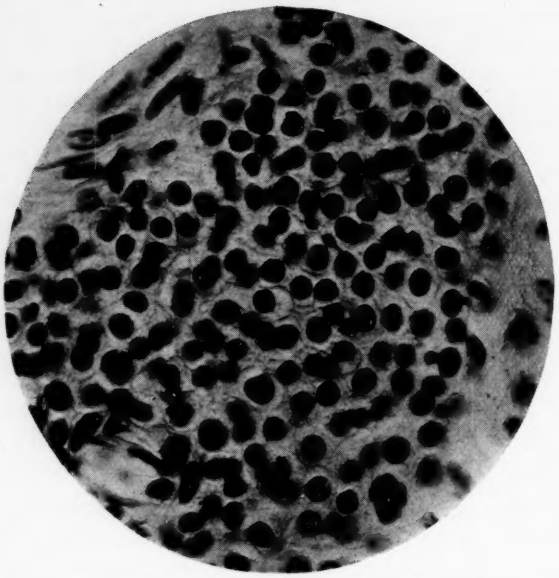


FIG. 172.—*Case* 1. This shows part of a perivascular sheet of typical glomus cells. The cells are uniform in size, cuboidal in shape, with rounded nuclei rich in chromatin, and show a distinct limiting membrane. (× 500.)

FIG. 173.—*Case* 1. General structure. The main tumour mass is cavernous in arrangement, with areas of fibromyomatous proliferation of the stroma. The lowest part of the field shows the periphery of the tumour. (× 15.)

and the indisputable smooth muscle cells present in the nodular areas (*Fig.* 175). Such appearances lend support to the hypothesis that glomus cells are essentially modified muscular cells; to these Masson applies the epithet 'myoid'. Some of the glomus cells show in their

cytoplasm the minute fuchsinophil granules and twigs which Masson considers in his material to be the precursors of smooth muscle fibrils. No mitoses are seen.

The peripheral regions of the growth show small myelinated nerve-trunks, while in the central area there are numerous groups of single myelinated fibres scattered about in the

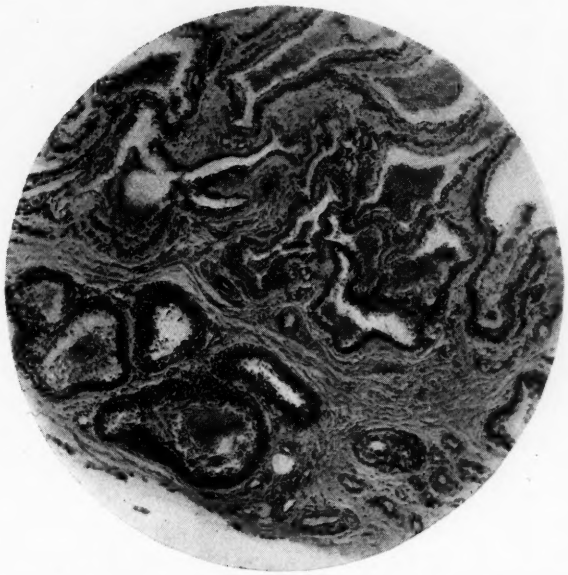


FIG. 174.—*Case* 1. Peripheral zone. The peripheral type of vessel, with its thick tunic of glomus cells, is seen below. Above, the blood spaces are larger and irregular, and the glomus cells are fewer. (× 50.)

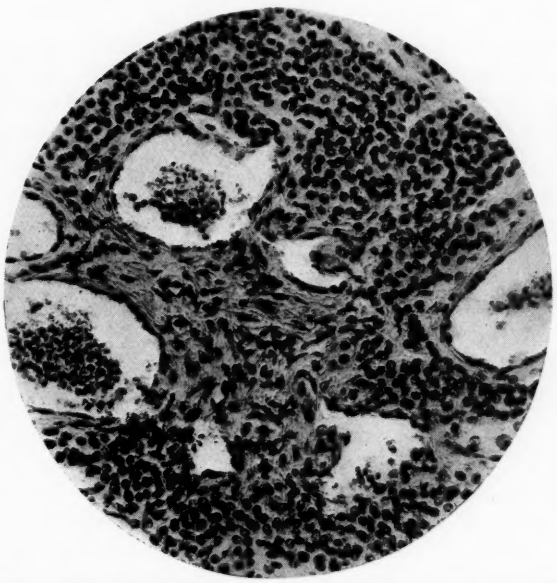


FIG. 175.—*Case* 1. This field shows a less orderly arrangement of vessels and glomus cells, the latter forming an almost continuous sheet. Note the gradual transition between typical cuboidal glomus cells and fusiform cells. (× 200.)

fibromyomatous stroma. The presence of non-myelinated fibres in our tissue, embedded as it is in paraffin, cannot be demonstrated to our satisfaction. No Pacinian corpuscles have been seen in the sections examined.

Elastic tissue (*Fig.* 176) is irregularly scattered throughout the stroma of the growth, showing no constant relationship to the glomus cells. In places it is finely distributed among them with a condensation either internal or external to the cell mass; elsewhere no fibres

FIG. 176.—*Case* 1. Central zone. This shows the elastica irregularly proliferated and with no constant relationship to the blood spaces. (*Weigert's elastica stain.*) (× 80.)

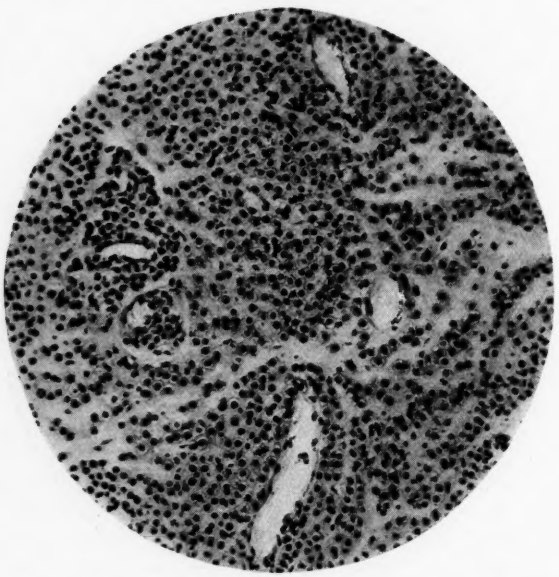


FIG. 177.—*Case* 3. This is from the central part of the tumour, and shows the small vascular spaces lying in a wide sheet of glomus cells. In parts, the glomus cells are dissociated by œdematous swelling of the stroma. (× 150.)

are seen among the glomus cells, but a distinct lamina separates them from the surrounding connective tissue. In the nodular areas of the stroma the elastica shows both the sharply stained coils characteristic of proliferation, and the flat appearance and fainter staining of degenerative change.

Case 2.—The histology of this case is so nearly identical with that of Case 1 that a separate description is unnecessary. The two lesions may be considered in essence as simple tumours in which all the elements of the normal glomus participate; in many parts there is a fairly accurate reproduction of the highly evolved structures characteristic of the parent organ.

Case 3.—The appearances in this case are, by contrast, less 'organoid', the proliferation being mainly of glomus cells, with but little demarcation of the tumour into zones. The general picture (*Fig.* 177) is of smallish vascular spaces lying in broad sheets of glomus cells. The spaces are lined by a prominent endothelium supported in most places by a layer of fibrillar tissue with rather indeterminate elongated cells. These seem to show transition to the surrounding glomus cells. Between the perivascular masses the glomus cells are less closely packed, and lie separated from each other in a loose œdematous ground-work. Areas are seen here also with cells apparently transitional between glomus and smooth muscle cells, but actual muscle elements are few and mainly lying loose; there is none of the comparatively firm fibromyomatous tissue seen in the other cases. No nervous elements are noted.

DISCUSSION

The main points of clinical interest in these tumours are the sites of origin, the pain, which may be extreme, and the occasionally associated autonomic upset.

Glomangioma may arise presumably wherever there are normal glomera. These are most abundant on the extremities, especially in the nail-bed and in the pulp. Of the 65 cases collected by Bailey, the tumours were on the hand in 30, and 20 of these were subungual. Four of Stout's 11 cases were subungual on the hand. The distribution on the leg shows no special distal localization, half of the 18 reported tumours having been on the thigh.

The pain which is such a characteristic feature of the majority of these tumours, especially when subungual, is described variously by the patients as bursting, stretching, or burning. It tends to originate in the tumour and to radiate over an increasing area, till in the end it may affect an entire limb or even more. It is frequently brought on by pressure or even a touch, so that the patient may develop a protective mannerism—for example, to prevent the clothes from touching the lesion; in other cases, changes of temperature elicit the spasms of pain. During the paroxysm, engorgement of the tumour has often been noted. On the other hand, the patient may fail to realize that the unobtrusive nodule is the source of his pain. The tumour may be present for years before pain makes its appearance, as in our *Case* 1; while in the case reported by Picard[10] and in our *Case* 3, the tumour was definitely painless. It is likely that tumours arising in the restricted tissue of the nail-bed bed will earlier cause pain than those in soft parts; this may account for the more frequent recognition of tumours in this site.

In one of the cases described by Masson (Barré's case), a subungual glomangioma on the left middle finger appeared to have given rise to disturbance of the autonomic nervous system, for the affected arm was warmer than the other, and there was a homolateral Horner's syndrome. These phenomena disappeared after excision of the tumour.

Bailey states that nearly half the recorded cases give a history of a single severe trauma to the site. So far as is known, it is unusual for trauma to play so important a part in the etiology of other simple neoplasms.

The clinical diagnosis of the typical case is easy, and depends principally on recalling the existence of these tumours. Many have been regarded as ordinary angiomata, of capillary or venous type, or as neurofibromata. In making a

differential diagnosis, one should consider also the various simple subungual growths, and, in addition, melanoma, myoma cutis, synovioma, rheumatic nodule, and painful cicatrix. On the other hand, the histological appearances have occasionally in the past been misinterpreted; the cellular nature of the growth leading even to the unfortunate diagnosis of sarcoma.

The treatment of most of the recorded cases was removal of the tumour under local anæsthesia; this led almost invariably to cure. Stout reports the second example of local recurrence. In a few instances pain persisted for a short period after operation.

The position is most aptly summarized by Picard's epigram: "Auch hier gilt, wie bei allen seltenen Erkrankungen als erste Bedingung, das Darandenken—die zweite, die Behandlung ist einfach: Exstirpation." (In dealing with this, as with all rare lesions, the most difficult step is to bring it to mind—this done, its treatment is simple: extirpation.)

The photomicrographs are by Mr. John Kirkpatrick, of the Department of Pathology, University of Glasgow.

REFERENCES

[1] BAILEY, O. T., *Amer. Jour. Pathol.*, 1935, xi, 915.
[2] GREIG, D. M., *Edin. Med. Jour.*, 1928, xxxv, 565.
[3] MASSON, P., *Lyon chir.*, 1924, xxi, 257.
[4] POPOFF, N. W., *Arch. of Pathol.*, 1934, xviii, 295.
[5] GRANT, R. T., and BLAND, E. F., *Heart*, 1931, xv, 385.
[6] LOVE, J. G., *Proc. Staff Meet. Mayo Clin.*, 1935, x, 593.
[7] RAISMAN, V., and MAYER, L., *Arch. of Surg.*, 1935, xxx, 911.
[8] LEWIS, D., and GESCHICKTER, C. F., *Jour. Amer. Med. Assoc.*, 1935, cv, 775.
[9] STOUT, A. P., *Amer. Jour. Cancer*, 1935, xxiv, 255.
[10] PICARD, H., *Zentralb. f. Chir.*, 1931, lviii, 2133.

THE PROBLEM OF ANURIA

A REVIEW OF RECENT WORK ON RENAL PHYSIOLOGY, WITH REPORTS OF TWO CASES

By ALAN W. CUBITT
SURGICAL REGISTRAR, MIDDLESEX HOSPITAL

THE cause and nature of anuria have been debated, at times hotly, for over a century, yet we are still little nearer to a solution than when Chopart in 1821 described a case of calculous anuria in which the post-mortem showed that the unobstructed kidney was apparently normal. It is noteworthy that this early case is an example of the most interesting and most puzzling type of anuria, which will be referred to in this paper as 'reflex anuria'. This term is chosen, not in any way to beg the question of the reflex nature of the condition, but for lack of any other term in general use. If I may define it more exactly, I would say that by it I mean a complete cessation of urinary output from the kidneys following an obstruction of one ureter in a subject whose other, unobstructed, kidney is capable of function.

There are two methods of approach to the problem, the clinical and the experimental, and both present peculiar difficulties which have prevented any certain, or indeed even strongly presumptive, conclusion from being reached. On the clinical side, the rarity of the cases, their rapid onset as emergencies in cases which have not as a rule been previously investigated, the difficulty of full investigation in patients so gravely ill, and the difficulty of interpreting post-mortem findings in terms of living physiology and pathology, combined with our ignorance of many of the details of the physiology and pathology of the kidney and of the true nature and cause of the intoxication produced by suppression of urine, all make the problem a very difficult one. The most striking and puzzling feature of reflex anuria is its rarity compared with the frequency of its apparent exciting cause. It is much to be regretted that case records have been notably lacking in certain important details which might have indicated a possible path towards a solution, or at least have prevented fruitless search along certain other paths. It may be that future cases carefully recorded will prove more helpful.

With regard to the experimental method, the difficulties are scarcely less formidable. So complicated is the structure of the kidney, and so numerous the factors concerned in the production of urine, that many aspects of its physiology are still uncertain. Nervous and hormonic influences, blood-pressure, the composition of the blood, its viscosity and osmotic pressure, temperature, urine pressure, are only some of the factors which have to be controlled and taken into account. Moreover, it is doubtful how far it is justifiable to apply knowledge gained by experiments on isolated and often denervated kidneys to the function of the kidneys in the living body. Again, different kidneys, even when isolated, show the same inexplicable and apparently capricious differences of behaviour under the influence

of apparently identical factors which are shown by kidneys in the living body. Lastly, the production of anuria by stimuli simulating those presumed to be active in cases of reflex anuria in human beings is exceedingly difficult. It was apparently achieved in a few cases by Goetzl[1] many years ago, but subsequent workers have failed to obtain his results.

Nevertheless, in spite of these difficulties in the way of a direct attack on the problem of anuria, fresh knowledge of the physiology of the kidney has gradually been gained by physiologists. So far this fresh knowledge does not appear to have been applied to the problem of anuria. The time has not yet come when it is possible to bridge the gap, but a short review of the recent physiological work may point the way to a more direct attack on the problem.

Types of Anuria.—Anuria is classified by Thomson-Walker[2] as :—

1. Circulatory (severe depression of blood-pressure).
2. Reflex.
3. Infective.
4. Obstructive.

Swift Joly's[3] classification is :—

1. Pre-renal (low blood-pressure).
2. Renal (infective and toxic).
3. Post-renal (obstructive).

It is the ' reflex ' type on which the chief interest centres.

Historical.—The question round which controversy has raged ever since Chopart's[4] case in 1821 is this : Assuming that a reno-renal or uretero-renal reflex exists, is it capable of producing a complete suppression of the function of a normal kidney, or only of a kidney already rendered more or less inefficient by disease ? Legueu[5] and Morris[6] held the view that though reflex anuria might occur, it only did so when the unobstructed kidney was diseased, never when it was perfectly healthy. More recently Winsbury-White[7] and Kelly and Birnam[8] have also expressed this opinion. Thomson-Walker[2] holds the same view, though he admits that a few cases have been recorded in which the unobstructed kidney was *apparently* healthy, though not proved to be so. On the other hand, Albarran,[9] Young and Davies,[10] Rovsing,[11] Watson,[12] and many others have expressed the opinion that reflex anuria might occur when the unobstructed kidney was normal. The difficulties in the way of a solution of this question are emphasized by a statement of Young's[10] that he has been unable to find any record of uræmic death due to reflex anuria where the unobstructed kidney could be shown to be healthy. He concluded, not that such cases of anuria do not exist, but that they always recover. Even should death occur, the unobstructed kidney would be found greatly congested (this point is further discussed below) as a result of the immediate condition, and this would of itself make it impossible to estimate small degrees of abnormality which might have been present before the anuria commenced. The conclusion seems to be that reflex anuria may occur in cases in which the unobstructed kidney has been shown to be so near normality as to make the question one of academic interest only.

Swift Joly[3] has recently raised a much more important and fundamental question. He states that in all cases of so-called reflex anuria there is a severe renal colic, and suggests that the suppression of urine in the unobstructed kidney is capable of being explained by the marked fall in the general blood-pressure caused by the

severe painful spasm of the obstructed ureter. There are, however, strong arguments against this theory. The pressure in the renal pelvis is nil, and filtration of urine should take place as long as the filtration pressure (that is, the pressure in the glomeruli) exceeds the osmotic pressure of the colloids in the blood-plasma. This may be taken as 25 mm. of mercury; the glomerular pressure is given as two-thirds of that in the renal artery; secretion of urine should therefore only cease when the blood-pressure falls below 45 mm. of mercury. In dogs and cats, whose blood-pressure is only slightly below that of a human being, it has been found that secretion of urine ceases when the blood-pressure falls below 30 to 40 mm. of mercury; other authorities give 75 mm. of mercury as the minimum blood-pressure in dogs at which secretion is possible. In any case it seems unlikely that the pressure would be sufficiently lowered by renal colic to produce a complete suppression of urine. It is unfortunate that, so far as I have been able to find, in none of the records of cases of reflex anuria has the blood-pressure been stated.

There is another important clinical observation which bears on the problem. Those who have seen the unobstructed kidney in cases of reflex anuria (it has been exposed on several occasions either deliberately or as the result of a mistaken diagnosis of the side obstructed) agree that it is enlarged and deeply congested (Rubritius,[13] Albarran[9]). Too little stress has been laid on this observation. It has been assumed by the advocates of a reflex action that anuria is brought about by a 'vascular cramp' of the kidney, but as Swift Joly points out, if this were the case, one would expect to find a small, pale, bloodless kidney. Frank,[14] reviving a suggestion of Israel's, postulates a "congestive reflex" in the unobstructed kidney, but his theory is stated in such vague terms as to be of little value, and he adds what may be the dangerous conclusion that if for any reason operation is not possible the correct treatment would be to lower the blood-pressure by purgation and fluid restriction.

CASE REPORTS

The following cases are recorded because of certain unusual features which they present, and of a new therapeutic measure employed in one of them.

Case 1.—E. C., a married woman of 60, very stout and rather 'wheezy', attended the Casualty Department of the Middlesex Hospital on July 21, 1935, with an attack of severe pain in the right side of the abdomen. The pain came on suddenly and was followed by retching and vomiting. It was situated all down the right side of the abdomen, and was not referred to the back or groin. The patient had had two similar attacks in the past two years, but they had not been so severe. She had never been jaundiced. She was referred to the Out-Patient Department, where I saw her the next day, July 22. The pain had then passed off. There was no abnormality of micturition, the bowels were open regularly. She had had rheumatic fever at the ages of eighteen and twenty-four. She had had eight children. Recently she had been treated for blood-pressure.

On Examination.—She had dyspnœa on exertion. There was no jaundice. The tongue was clean, and she had a high-pressure pulse. There was an ill-defined bulging of the abdominal contents between widely divaricated rectus muscles. There was tenderness on pressure over the right side of the abdomen, maximal over the gall-bladder. I agreed with the diagnosis of gall-stone colic which had been made in the Casualty Department and ordered a cholecystogram. Three days later I received a message asking me to see the patient, who was in the X-ray Department having the last of her cholecystograms taken. I found that she had passed urine on the evening of July 22, the day I had seen her, three days before, but had passed none since. On examination she appeared, and said she felt, quite well. The

tongue was clean and moist; there was no œdema. She had had no more pain. The bladder was catheterized and found to be empty. Cystoscopy was performed; the bladder was very intolerant and held only two ounces. There was a red œdematous swelling in the position of the right ureteric orifice, which was not itself seen. The left ureteric orifice had a normal appearance, but no efflux was seen. She was admitted under the care of Mr. (now Sir) Alfred Webb-Johnson, and radiographs of the urinary tract were immediately taken.

RADIOGRAPHY.—The cholecystograms which had just been completed showed a normally filling and emptying gall-bladder, and no calculi either in the urinary or in the bile passages. The right kidney shadow was, however, extraordinarily distinct, in spite of the obesity of the patient; there was no visible shadow of the left kidney. Radiographs of the pelvis were not very clear on account of the patient's obesity, and on account of the shadow in the colon of unabsorbed opacol.

July 26.—The day after admission and the fourth day of anuria she was drowsy and vomited several times. She was a little puffy under the eyes; there was no œdema of the ankles and no twitching. She passed 2½ oz. of urine at 7 a.m. The blood-urea was 250 mg. per cent. A hot-air bath caused her to sweat profusely. At 3 p.m. she was catheterized and the bladder found empty. The blood-pressure was 180 systolic. At 5 p.m. continuous intravenous infusion of normal saline by the drip method was commenced, and at midnight she was given 10 c.c. of 20 per cent saline by the same route; the total amount of saline was 4 pints.

July 27.—In the early hours of the morning she passed 11 oz. of urine, and during the twenty-four hours the total passed amounted to 74 oz.

July 28.—She passed a small oval grey smooth stone. There had been no more pain. From this time she had been passing satisfactory quantities of urine. Up to this time the temperature had been raised occasionally to 99°, and the pulse had been between 64 and 72.

July 29.—Blood-urea 180 mg. per cent. On close questioning she gave a history of a single attack of left-sided pain about Christmas, 1934.

July 31.—Blood-pressure 170/80. Urine: specific gravity 1010, alkaline reaction, contained albumin. The urine continued to show albumin until her discharge.

Aug. 6.—Blood-pressure 150/60. Blood-urea, 77 mg. per cent. Microscopical examination of the urine showed triple phosphate crystals, no casts.

Aug. 10.—Radiographed. Preliminary film showed no visible shadow of either kidney. Five minutes after intravenous injection of 20 c.c. of uroselectan B the pelvis and calices of the right kidney were visualized. The left kidney showed no secretion of uroselectan throughout the investigation.

I was anxious to perform a chromo-cystoscopy so as to establish the functioning or non-functioning of the left kidney, but the patient resolutely refused any further investigations, and discharged herself on Aug. 14.

Points of Interest.—

1. The mistaken diagnosis.
2. The failure of the calculus to show in the radiographs.
3. The exceptional density of the shadow of the right kidney in the radiographs taken during the period of anuria.
4. The unusual signs and symptoms of anuria.
5. The recovery of a severe case of anuria without operation.

Discussion.—The case unfortunately throws no light on the problem of reflex anuria. So far as the evidence went, the obstructed right kidney was the sole functioning organ; it is possible that the function of the left kidney had been destroyed by impaction of a stone—invisible on the radiographs, or since passed without her knowledge—which had caused left renal colic at Christmas. The very clearly defined shadow of the obstructed kidney is of great interest, and has not, to my knowledge, been previously noted. It is presumably due to the congestion of the kidney, and in certain cases in which there is uncertainty as to the side obstructed, might help the surgeon to decide on which side to perform a

nephrostomy. In cases of reflex anuria, however, if it is true that both kidneys are greatly congested, one would expect to see a dense kidney shadow on both sides in a radiograph. Even so the observation would be of value in showing that both kidneys were capable of function. The anuria was unusual in its symptoms, in that the period of tolerance was short (three and a half days) and there was puffiness of the eyelids. The presence of a previous chronic nephritis is suggested by the history of pre-existing high blood-pressure and the persistence of albuminuria for sixteen days after urinary secretion was re-established; no casts were found, however. The patient was a bad operative risk, and the conservative treatment was justified by its result in this case, though not to be recommended in a case of equal severity in a subject of better operative risk. Secretion was only re-established after relief of the obstruction by passage of the stone into the bladder; but it would be tempting Providence too much to rely on this happy event taking place at the critical moment in every case.

Case 2.—K. D., a girl of 15, was admitted to the West London Hospital under the care of Mr. G. F. G. Batchelor, on June 10, 1932. She complained of attacks of severe pain in the right groin, of a griping nature, without definite radiation; lasting six or seven hours; occurring about once a week; and accompanied by vomiting. They had been going on for about eighteen months. Micturition was unaffected. Radiography of the urinary tract showed slight distortion of the calices on the right side. Examination of a catheter specimen of urine on June 18 showed no pus and a few *Staph. albus*. Cystoscopy on June 28 showed a normal bladder, and ureteric orifices from which clear effluxes were seen. The ureters were catheterized, and specimens from both sides showed no pus and were sterile on culture. The urea content was, on the right, 1·0 per cent, and on the left 1·5 per cent.

July 5.—*Operation.* The right kidney was exposed and found to be very low and extremely mobile; the pelvis was slightly dilated. Nephropexy was performed by Thomson-Walker's method and the wound closed except for a tube drain.

July 8.—She was well and passing water freely. The temperature remained a little raised (maximum 100°), but settled to normal on the twelfth post-operative day. She was passing from 40 to 80 oz. of urine per day.

July 20.—She was allowed to get up.

July 21.—She complained of some pain in the left side. Passed 30 oz. of urine.

July 22.—She vomited several times during the night, and had two convulsive attacks during the morning; these consisted of colonic and tonic stages; she bit her tongue in one attack. She passed no urine after midnight, and catheterization revealed an empty bladder. The blood-pressure was 180/120. The blood-urea was 82 mg. per cent. The right kidney was palpable.

July 23.—The convulsions continued and she was unconscious. She was still secreting no urine. The temperature shot up to 106°; and the pulse to 160. She was given 30 oz. of 4 per cent glucose intravenously. A spinal anæsthetic of 0·4 cg. of stovaine was given. Cystoscopy was performed, and both ureters catheterized, and a flow of urine commenced. The catheters were left in, and drained 40 oz. of urine during the next twelve hours. There were no more convulsions, and improvement was rapid. The temperature remained swinging up to 101° and 102° for another ten days, there was pus in the urine, and the right kidney was palpable and tender.

Aug. 12.—The blood-urea was 30 mg. per cent. On Sept. 9 she was discharged.

Points of Interest.—

1. Both kidneys were proved to be healthy before operation.

2. The anuria seems to have been due to the effect of an acute and virulent infection, possibly with an added element of obstruction by a clot (which was seen in the bladder on cystoscopy). It is impossible, however, to place the case definitely in one category or the other.

3. The symptoms seem to have been due to a sudden intense toxæmia due to an acute infection, and not to uræmia.

4. The blood-pressure was raised.

5. A form of treatment—spinal anæsthesia—not to my knowledge previously described, was used.

Discussion.—It occurred to me after considering the teaching of the late Mr. Tyrrel-Gray on the part played by a sympathetic reflex in ileus, and the effect which a spinal anæsthetic sometimes has in that condition of causing a spontaneous action of the bowels, that if, in this case, there was obstruction of one ureter by a blood-clot, and a consequent reflex effect on the other kidney, a spinal anæsthetic should break the reflex arc and enable the unobstructed kidney to resume its secretion. Mr. Batchelor, under whose care the case was, kindly allowed this suggestion to be carried out. Since, in this case, on account of the desperate condition of the patient, three different therapeutic measures were all employed in rapid succession, it is impossible to attribute the successful result which was obtained to any one of them separately. I believe, however, that in a case of reflex anuria a spinal anæsthetic should be a valuable addition to our therapeutic armamentarium. In order to be effective it should on theoretical grounds produce anæsthesia reaching as high as the sixth dorsal segment. Even a much lowered blood-pressure would be no contra-indication, for in shock due to peripheral-nerve stimulation a spinal anæsthetic raises the blood-pressure by cutting off the stimuli which have caused it to be depressed (O'Shaughnessy and Slome[15]).

In this connection Neuwirt's case[16] quoted by Swift Joly is of interest. In a case of severe unilateral renal colic, unrelieved by morphia, with extreme oliguria (330 c.c. in twenty-four hours), he injected novocain round the semilunar ganglia on both sides. The pain was relieved in fifteen minutes and 2000 c.c. of urine were excreted in the next twenty-four hours. Cystoscopy next day showed that both kidneys were working. Unfortunately Neuwirt does not record the blood-pressure, so that this interesting case, which might have settled one of the problems of reflex anuria, leaves it still unsolved. This method of posterior splanchnic block has the disadvantages that it is not without danger, and that it requires an experience which few, at any rate in this country, possess. The method of spinal anæsthesia is almost free from these disadvantages, and it is advanced as having a possible value in certain cases of reflex anuria, before recourse to the more drastic method of nephrostomy.

ANATOMY

Nerve-supply.—The kidney is supplied by nerve-fibres from both the sympathetic and the vagus, which run to the hilum on the surface of the vessels of the pedicle. Those from the sympathetic are derived mainly from the 6th dorsal to the 1st lumbar segments of the cord, though possibly some fibres come from as high as the 4th dorsal segment. There is no experimental indication of the function of the vagus, nor is there evidence of any direct effect of either vagus or sympathetic on the secretory cells.

Blood-supply.—The vascular system of the kidney is peculiar. The arterioles from the vasa recta break up into a capillary plexus in the glomeruli; these capillaries reunite into a second set of arterioles, which again break up into a second capillary

plexus around the convoluted tubules. The second capillary plexus drains into the venous radicles. Hence the capillaries of the glomeruli lie between two sets of arterioles capable of contraction and relaxation.

RECENT WORK ON THE PHYSIOLOGY OF THE KIDNEYS

There is evidence that the two sets of arterioles—afferent and efferent in relation to the glomerular capillaries—are independent and different in their response both to nerve stimulation and to drugs and hormones, and that by their contraction and relaxation they control the glomerular pressure which is the most important single factor in determining the output of urine. The capillaries themselves have not been shown to have any active contractile power.

We may briefly summarize the work which has elucidated the behaviour of these vessels under different conditions. Most of this work has been done by perfusing kidneys with different concentrations of adrenalin. Low concentrations and high concentrations of adrenalin have different effects, and it appears that this is due to a difference in the reactions of the afferent and efferent arterioles.

Richards and Plant[17] showed that in low concentrations adrenalin caused an increase in the kidney volume and an increased flow of urine, and suggested that it did so by constricting the efferent vessels and thus increasing the glomerular blood-pressure. Later, in collaboration with Schmidt,[18] Richards confirmed his theory by direct microscopical observation of the glomerular capillary tufts in the kidneys of frogs, perfused with different concentrations of adrenalin. With low concentrations, the number of patent glomeruli increased, and the glomerular tuft enlarged; it became more densely congested with blood-cells, and the rate of flow of the cells through it was slowed. They concluded that this was due to constriction of the efferent arterioles. With higher concentrations there was a diminution of the number of patent glomeruli, of the lumen of the individual capillary, and of the number of patent capillaries in any one glomerulus; these effects they concluded were due to constriction of the afferent arterioles. It is also of interest to note that a decrease in the number of patent glomeruli is caused by stimulation of a lower dorsal sympathetic ramus, of the sciatic nerve, and by large doses of pituitrin, while increase in the number of patent glomeruli is caused by section of the lower dorsal sympathetic rami, by anoxæmia, by the diuretics sodium chloride (isotonic), glucose, urea, and caffeine, and by pituitrin in small amounts. The effectiveness of this mechanism is strikingly illustrated by an observation of Hayman and Starr[19] that, whereas under the influence of caffeine all the glomeruli were patent, high concentrations of adrenalin might cause closure of all but 10 per cent.

Winton[20] carried the investigation a stage further by perfusing isolated heart-lung-kidney preparations with defibrinated blood containing varying concentrations of adrenalin, and recording the blood-flow from the renal vein and the urine-flow from the ureter. With weak concentrations he found that in the majority there was increased flow of urine and decreased flow of blood. As a result of mathematical deductions as to the glomerular blood-pressure, he concluded that the effect on the arterioles was (1) dilatation of the afferents, and (2) constriction of the efferents. There were, however, two kidneys out of seventeen which behaved anomalously and showed a diminished flow of urine and a diminished blood-flow. With higher concentrations of adrenalin he found a diminished flow of urine and a diminished

blood-flow. He concluded that both the afferent and the efferent arterioles were constricted. He makes another interesting observation that the effect of adrenalin was antagonized by ergotoxin.

The effect of nerve section and nerve stimulation has not been worked out in such detail, but in general is as follows (Fee[21]) :—

1. Section of the nerves of the renal pedicle—increased blood-flow, increased kidney volume, increased flow of urine.

2. Weak stimulation of the nerves of the pedicle—increase in volume of kidney and in flow of urine.

3. Strong stimulation of the nerves of the pedicle—decrease in kidney volume and in flow of urine.

Thus it appears likely that the afferent and efferent arterioles respond to nerve stimulation in the same way as to adrenalin.

In this work there are several points which may have some bearing on the problem of anuria.

1. The important role played by the efferent arterioles in the control of glomerular pressure and the flow of blood through the glomeruli.

2. The independence of action and difference in reaction both to drugs and to nervous stimuli shown by the afferent and the efferent arterioles.

3. There appears to be a balance between the two systems of arterioles which varies in different kidneys. One is reminded of sympathetic-parasympathetic balance, which varies in different species, in different individuals of the same species, and in different emotional, reflex, and metabolic states in the same individual. The difference of response of different kidneys to caffeine supports this conclusion. In all cases caffeine causes an increase in blood-flow through the kidney; the diuretic effect is less constant—sometimes it is marked, sometimes absent. The explanation given by Verney and Winton[22] is that, while in most cases the dilatation of the afferent vessels is greater than that of the efferent vessels, causing a rise in glomerular pressure, in those cases in which diuresis fails to occur, this is not the case, but both dilate equally. This inconstancy of behaviour marks all experimental work on kidneys. On the clinical side it suggests an analogy with the rarity of reflex anuria compared with the frequency of its apparent exciting cause.

The Anuria of Exercise.—It has been shown[23] that anuria occurs during severe muscular exercise in spite of a marked rise of blood-pressure.

The Influence of Hormones.—Theobald and Verney[24], working with kidneys which had been completely denervated, caused inhibition of water diuresis by afferent-nerve stimulation. They advance reasons for thinking that the effect is produced on the arterioles by a hormone liberated by nerve stimulation. They believe that this hormone is not adrenalin, but may be post-pituitrin, which is well-known to have a similar inhibiting effect on water diureses. The effect is not due to lowering of blood-pressure. They suggest that the anuria of exercise may also be due to a hormone.

Reabsorption in the Tubules.—Duncan Morison[25] states that in hydronephrosis the contents of the renal pelvis are constantly being changed. If glomerular filtration is still going on there must be some process of re-absorption. He investigated the nature of this re-absorption by introducing various dyes and Indian ink into the pelvis, and obstructing the ureter. He found that there are

two routes of re-absorption, by the lymphatics and by the tubules. If foreign substances, and even particulate substances such as Indian ink, can be absorbed by the cells of the convoluted tubules, it would appear probable that not only water and threshold substances, as usually believed, but non-threshold substances also—in fact, the entire glomerular filtrate—can be re-absorbed when there is obstruction to the outflow from the tubules. There are other experimental indications that this may be the case.

The Effect of Ureter Pressure.—If the ureter pressure is gradually raised, there is at first no decrease in the flow of urine, but if it is progressively raised beyond a certain point, usually about 10 mm. of mercury, the output of urine falls, and finally ceases when the ureter pressure reaches 20 or 30 mm. of mercury.

The Effect of Venous Obstruction.—Partial venous obstruction produces a congested kidney with a diminished blood-flow and diminished output of urine. The engorged venules press upon the urinary tubules and obstruct them, thereby raising the urine pressure (Winton[26]). As with the ureter pressure, there is a critical pressure below which an increased venous pressure has no effect on the flow of urine. This critical point is the same for both venous pressure and ureter pressure. Moreover, in partial venous obstruction, increase of ureter pressure has no effect on the urine flow unless the ureter pressure exceeds the venous pressure.

These observations suggest that in the normal unobstructed kidney there is a certain intrarenal pressure acting in all directions within the capsule of the organ, and tending to obliterate the tubules, thus offering a certain constant resistance to the production of urine. The raised intrarenal pressure associated with œdema or engorgement may be an important factor in producing the oliguria which occurs in certain diseased conditions of the kidneys (Winton[27]). It seems to me that this conception of intrarenal pressure may be the key to the problem of anuria.

The Factors which Influence the Output of Urine.—From the above considerations, it is now possible to obtain a fairly clear picture of the factors determining the output of urine. They are :—

1. *The Urine Pressure.*—This is normally nil, but may rise as a result of partial or complete obstruction of either the ureter or the tubules. Obliterative pressure on the tubules is one of the effects of venous obstruction.

2. *Changes in the Secretion-reabsorption Activity of the Tubule Cells.*—We still lack precise knowledge of this activity, but it would appear probable that it depends, like that of other secretory processes, on the blood-supply of the cells. There are also indications, previously discussed, that it is modified by the urine pressure.

3. *The Blood-pressure in the Glomerular Capillaries.*—This pressure, less the osmotic pressure of the serum proteins and the urine pressure, is the effective filtration pressure. It is increased by: (*a*) Rise in general blood-pressure; (*b*) Relaxation of the afferent arterioles; (*c*) Contraction of the efferent arterioles.

4. *The Area of the Capillary Bed from which Filtration is taking Place.*—This depends on the state of contraction or relaxation of the afferent and efferent arterioles, and on general blood-pressure. In a kidney under normal conditions only a small fraction of the glomerular capillaries is open to blood-flow; the number is greatly increased during diuresis, and under other conditions it may be diminished.

5. *The Osmotic Pressure of the Colloids in the Plasma of the Blood Contained in the Glomerular Capillaries.*—It is probable that if any change occurs it is of so slight a degree as to be negligible in its effect on urine filtration.

Causes of Anuria.—If we apply this conception of the production of urine, it is evident that there are several possible causes of anuria.

1. *Urine Pressure.*—Increased urine pressure caused by obstruction of the ureter or the tubules. Obstruction of the tubules is a result of venous obstruction, and we may assume that it is also a result of a rise in intrarenal pressure due to œdema of the renal parenchyma.

2. *Arterial.*—(*a*) Marked fall of general blood-pressure; (b) Contraction of afferent arterioles.

3. *Venous.*—Obstruction of veins.

Hypothesis as to the Nature and Causation of Reflex Anuria.—Bearing in mind that the evidence is in favour of a congested kidney in reflex anuria, it is possible that the sequence of events may be thus: Spasm of one ureter in response to impaction of a stone sets up afferent nervous impulses which, either by direct reflex action or by release of some hormone substance, cause vascular changes in the other kidney, an alteration in capillary permeability, and an exudation of fluid into the renal parenchyma; the raised intrarenal pressure obstructs the tubules and raises the urine pressure opposing filtration; at the same time it causes partial obstruction to the venous outflow so that the kidney is congested with blood. Contributory factors may be: (1) Lowering of general blood-pressure; (2) Abnormal leak of urine back through the tubules into the blood-stream, as a result of increased urine pressure.

Such a tentative hypothesis, while it is of no value in itself without proof, may be of some value in suggesting lines of attack on the subject. It brings reflex anuria into some relation with toxic anuria (in which the kidneys are congested and œdematous, and have on occasion been restored to function by release of intrarenal pressure by decapsulation), and with those cases of anuria following urethral or ureteral instrumentation which are variously classified as toxic and reflex.

It is possible of course that reflex anuria may be of varied types, and that in some cases the anuria may be due to a reflex vascular spasm.

Another interesting possibility is suggested by recent work on pyeloscopy. It has been shown that the calices and pelvis have a regular cycle of diastole and systole, and that during the diastole of a calix the connecting channel between calix and pelvis is completely shut. Spasm of the circular muscles of these channels or of other portions of the upper urinary tract may be caused reflexly by disease of the gall-bladder, appendix, or viscera having an associated nerve-supply, and may disappear when the diseased organ has been dealt with (Jona,[28, 29]). This suggests the possibility that the suppression of urine from the unobstructed kidney in reflex anuria might be due to an intense reflex spasm at the pelvi-ureteric junction or the necks of the calices.

The value of ureteric catheterization is now well recognized; it may be that it drains urine pent up above such a spasm. It was suggested many years ago by Essex Wynter, though never published by him.

SUMMARY

1. The nature of the problem of reflex anuria is stated, and a brief review of the history of the controversy is given. The conclusions reached are, firstly, that the unobstructed kidney which is the subject of reflex anuria may be free from gross

disease, and secondly, that the 'vascular cramp' theory of reflex anuria fails to account for the observed fact that the unobstructed kidney is swollen and congested. There are certain objections to the theory that the anuria is due solely to lowering of blood-pressure. It is pointed out that a record of the blood-pressure in all cases of reflex anuria would help to solve the problem in its clinical aspect.

2. Two cases of anuria are reported. While neither of these can be certainly put in the class of reflex anuria, they both present unusual and interesting features. In the first case the obstructed kidney showed as a very dense shadow in the radiograph, presumably on account of its congestion. The contralateral kidney was probably functionless. The ureteric calculus which was subsequently passed did not show in the radiograph. The symptoms of anuria were early in their appearance. Restoration of the flow of urine, probably due to passage into the bladder of the stone blocking the ureter of a solitary functional kidney, followed the administration of intravenous saline.

In the second case complete anuria followed nephropexy; both kidneys had previously been proved to be functioning perfectly. The cause was probably partly obstructive and partly infective. The symptoms were unusually early and severe. Restoration of the flow of urine and relief of symptoms followed a combination of intravenous glucose, a spinal anæsthetic, and bilateral ureteric catheterization.

Spinal anæsthesia is put forward as a rational therapeutic measure worthy of trial in cases of reflex anuria. This applies whatever its etiology, since the afferent path at least must be a nervous one.

3. There has been a considerable amount of experimental work done by physiologists in the last few years dealing with the blood-supply of the kidneys, its response to humoral and nervous influences, and the effect on the secretion of urine of these changes in blood-supply, and of changes in the urine pressure. This work has an important bearing on the problem of anuria, and does not seem to have been noticed in the surgical literature. Winton's conception of intrarenal pressure in particular is full of possibilities, and requires further work. A short summary of this recent physiological work is given, and a tentative explanation of reflex anuria is suggested.

I wish to express my thanks to Sir Alfred Webb-Johnson and to Mr. G. F. Grant Batchelor for permission to report the cases under their care, and for their encouragement and helpful suggestions and criticism, and to Dr. F. R. Winton, whose fine work has led to a new conception of renal physiology, for giving me the benefit of his expert knowledge and criticism.

REFERENCES

[1] GOETZL, A., *Pflüger's Archiv. f. d. ges. Physiol.*, lxxxiii, 128.
[2] THOMSON-WALKER, SIR J., *Urological Surgery*, 1914.
[3] SWIFT JOLY, J., *Stone and Calculous Disease of the Urinary Organs*, 1929. Heinemann.
[4] CHOPART, quoted by Eliot, H., *Ann. d. Mal. d. Org. gén.-urin.*, 1911, i, 107.
[5] LEGUEU, P., *Clinique*, Paris, 1914, ix, 482.
[6] MORRIS, SIR H., *Diseases of the Kidneys and Ureters.*
[7] WINSBURY-WHITE, *Stone in the Urinary Tract*, 1929. Churchill.
[8] KELLY and BIRNAM, *Diseases of the Kidneys, Ureters and Bladder*, 1922, ii, 112.
[9] ALBARRAN, Congrès d'Urologie, 1898, quoted by Eliot, H., *Bull. Soc. anat.*, 1909, June, 353.

[10] YOUNG, H. H., and DAVIS, D.M. *The Practice of Urology*, 1926, i, 385. Saunders.
[11] ROVSING, *Zeits. f. urol. Chir.*, xii, Nos. 3 and 4.
[12] WATSON, J., *Amer. Jour. Med. Sci.*, 1909, cxxxvii, 550.
[13] RUBRITIUS, H., "Die Klinik u. Therapie d. Anurie", *Verh. d. Deut. Gesells. f. Urol.*, VII Kongress, 1926, 233.
[14] FRANK, L., *Surg. Gynecol. and Obst.*, 1915, xx, 526.
[15] O'SHAUGNESSY and SLOME, *Brit. Jour. Surg.*, 1935, xxii, 589.
[16] NEUWIRT, *Zeits. f. urol. Chir.*, xi, Nos. 3 and 4.
[17] RICHARDS and PLANT, *Amer. Jour. Physiol.*, 1922, lix, 144.
[18] RICHARDS and SCHMIDT, *Ibid.*, 1927, lxxi, 178.
[19] HAYMAN and STARR, *Jour. Exper. Med.*, 1925, xlii, 641.
[20] WINTON, F. R., *Jour. of Physiol.*, 1931, lxxiii, 151.
[21] FEE, *Ibid.*, 1929, lxviii, 305.
[22] VERNEY and WINTON, *Ibid.*, 1930, lxix, 153.
[23] MACKEITH, PEMBREY, SPURRELL, WARNER, and WESTLAKE, *Proc. Roy. Soc.* (B), xcv, 413.
[24] THEOBALD and VERNEY, *Jour. of Physiol.*, 1935, lxxxiii, 341.
[25] DUNCAN MORISON, *Proc. Roy. Soc. Med.*, 1928, xxii, 219.
[26] WINTON, F. R., *Jour. of Physiol.*, 1931, lxxii, 49.
[27] WINTON, F. R., *Proc. Physiol. Soc.*, 1933, Feb. 18; *Jour. of Physiol.*, lxxvii.
[28] JONA, J. L., *Surg. Gynecol. and Obst.*, 1933, lvi, 632.
[29] JONA, J. L., *Ibid.*, 1934, lix, 713.

SOME CONTRIBUTIONS TO THE CAUSATION, PATHOLOGY, AND TREATMENT OF DUODENAL ULCER AND ITS COMPLICATIONS

By T. H. SOMERVELL and I. M. ORR

SURGEONS, LONDON MISSION HOSPITAL, NEYYOOR, TRAVANCORE, S. INDIA

THE etiology of gastric and duodenal ulceration, together with certain aspects of its prognosis under varieties of treatment, medical and surgical, is still the subject of controversy throughout the world. The literature abounds with accounts of the relative merits of medical and surgical treatment, and the Continental surgeons vie with their British colleagues in arguing the case for radical as against conservative surgery. Meanwhile, thousands are suffering from this disease with imperfect treatment of one sort and another; and more recently the advent of histidine has raised the hopes of many, although observers in some hospitals have found it to be uncertain in its results.

The literature of duodenal ulceration is extensive, and there would be little excuse for adding to it, unless one had some definite contribution to make towards the solution of the problem of its treatment. The series of cases whose treatment and observation forms the subject of this paper is a large one, consisting of 2500 consecutive cases, all treated at the same clinic; and all treated surgically, though by various methods, either by or under the personal supervision of the authors of the paper. While this clinic is in India, a country with special conditions which influence the course of disease, and with a village population the nature of which prevents in many cases a satisfactory follow-up of patients, it is hoped and believed that the findings from these cases will prove to be of value in the search for truth which it is incumbent upon all surgeons to prosecute. If it can help to decide what is still a vexed question—namely, what is really the best treatment for duodenal ulcer, and whether that treatment should vary according to the condition of the ulcer, or should be standardized—it will have achieved its object. It is hoped, therefore, that lessons learned in India may afford a definite contribution to the knowledge in possession of surgeons in other parts of the world.

In South India, so-called peptic ulcer is very common—six hundred times as common as in the north. Probably five in every thousand of the adult population of Travancore suffer from duodenal ulcer; gastric ulcer is not nearly so frequent an occurrence. On one occasion, one of us (T. H. S.) operated on five brothers, all of whom were suffering from ulcer of the duodenum. But even in the State of Travancore, comprising the southern 200 miles of the West Coast of India, the distribution of peptic ulcer is not uniform. In the extreme south of the State it is comparatively rare; on the sea-coast it is less common than inland; and in the northern, and especially the central, half of the country, it is very prevalent indeed.

Dr. S. H. Pugh, at Neyyoor Hospital, S. Travancore, was the first surgeon

to perform gastro-jejunostomy for duodenal ulcer in South India; this he did against the advice of his medical colleagues, who protested against surgical treatment for dyspepsia. A similar experience befell Major Bradfield in Madras (now Surgeon-General) a few years later. But both these surgeons justified themselves, and to-day surgeons of the Madras General Hospital are operating on hundreds of these cases every year, while in Travancore over 600 operations for duodenal ulcer are performed annually.

The observations in this paper are based on an experience of 2500 cases of duodenal ulcer, operated upon by various methods during the last ten years at the Neyyoor Hospital. While the follow-up of many of these cases is of necessity imperfect, so many of the patients having been poor and uneducated villagers, yet there are few hospitals where such a large continuous series of cases is available; and more than 600 cases have been followed up and personally examined.

PHYSIOLOGY

The stomach when considered physiologically is usually regarded as divided into four portions (*see Fig.* 181):—

1. The cardiac portion, the glands (tubuloracemose) of which secrete mucus; oxyntic cells are frequent, and a certain amount of the acid secretion of the stomach is done here.

2. The fundus, in which there are (*a*) short tubular glands lined with 'central' cells which appear granular and are said to secrete pepsin, (*b*) lateral (oxyntic) cells which have a prolongation of the tubule into them, and secrete acid. The major portion of the acid is secreted in the fundus.

3. The 'gastric pathway' or small curvature and pre-pyloric portion. Here there are no oxyntic cells; the mucous membrane is less mobile; lymphoid nodules are numerous; and mucin is secreted abundantly. The glands are long and tubular, and are formed of cells of one kind only, supposed to secrete pepsin, and probably also secreting an acid-producing hormone.

4. The pyloric antrum, containing cells which secrete mucus and long tubular glands secreting pepsin. The secretions from the pyloric antrum are said to produce the anti-anæmic factor; and anæmia of the microcytic hypochromic type is a recognized complication of operations such as Polya's gastrectomy in which the pyloric end of the stomach has been removed, and is not a common complication of gastrectomies in which the pyloric antrum is left, the middle portion of the stomach being removed. Conflicting reports have been made of this question of anæmia, and Morley[15] states that anæmia is rare after Schoemaker's operation, in which it is just this pyloric portion that is removed. Gordon-Taylor[16] reported a high rate of anæmia—44 per cent of cases—after gastrectomy, while Lake[17] in a similar series found anæmia to be very rare.

The results of our operations seem to show that if a portion of the pyloric antrum is left, gastrectomy is not followed by secondary ulceration of the gastro-jejunal type, and this important result makes it worth while preserving the pyloric antrum whenever it is possible to do so. Further research is required as to the question of anæmia; but it is certain that Addisonian anæmia is rare after gastrectomy, and the usual microcytic type can be so easily relieved by the administration of ferrous salts that it is not a very serious consideration.

PATHOLOGY

The duodenal ulcers of South-west India show certain atypical characteristics; nevertheless the proportion of gastro-jejunal ulceration after gastro-enterostomy in our series of cases is exactly the same as it is in similar series collected elsewhere (*see* especially Garnett Wright's series reported in the *British Journal of Surgery*, 1935, xxii, 433). This would indicate that the lesion is essentially the same as it is in other countries; but the fact remains that there are certain features of our cases which are by no means typical.

The most striking feature is the rarity of perforation; in our series of 2500 ulcers, only 4 cases of perforation were seen. Hæmorrhage also is very rare. These exceptional features are consistent with the known and very striking tendency of the Indian abdomen to chronic rather than acute ailments. Chronic appendicitis

FIG. 178.—Pylorus from two cases of early duodenal ulcer. A, Three months' history—slight duodenitis; B, Eight months' history—marked duodenitis with small healed ulcer. (Natural Size.)

is very common, and acute appendicitis is rare; only 20 cases were recorded at Neyyoor last year out of 3000 major operations, whereas over 200 cases of chronic appendicitis were operated upon. Similarly, duodenal ulcer tends to be chronic rather than acute; and, together with the rarity of perforation, we have noticed the extreme frequency of large cicatrized masses of scar tissue, with stenosis of the duodenum and a tremendously dilated stomach. We see this condition in over 40 per cent of all ulcers of the duodenum or pylorus in South India.

As far as the histology of the stomach is concerned, there is a great prevalence of changes in the mucosa at a distance from the ulcers, obviously indicating a common pathological change throughout a great part of the stomach, of which the ulcer itself is but a local exaggeration. In the earliest stages (*Fig.* 178) there is

found at the pylorus, especially on the duodenal side thereof, a congestion of the mucosa which indicates a duodenitis, and which clinically is associated with pyloric spasm, hunger pain, gastric hyperacidity, and in fact is indistinguishable from a case of definite duodenal ulceration.

In several of these cases multiple small superficial ulcers in the pyloric region have been found at the time of operation, but they are of early occurrence and apparently heal up in a few months as the simple duodenal ulcer develops. At a considerable distance from the pylorus there is an increase in the size and frequency of lymphoid nodules and the mucous membrane shows an aggregation of lymphocytes; occasionally this is very dense and continuous throughout the gastric mucosa, which is (with the entire submucosa) densely infiltrated with round cells. The glands of the mucosa are distorted, the tubules short and filled with cells. Lymph nodules in the worst cases showed areas of necrosis in their centres, suggestive of small abscesses; possibly the breaking down of one or more of the lymphoid follicles in this way is the actual determining factor in starting an ulcer, and is almost certainly the process by which the multiple ulcers are formed.

Thus it appears that a chronic gastritis and/or duodenitis is the precursor of ulcer. This finding is in accordance with that of Aschner and Grossmann, of New York, Konjetzny,[1] Puhl, etc.[2] (See also Carswell,[3] Faber[4]; Hurst and Stewart are of different opinion, but on negative grounds—*Gastric and Duodenal Ulcer*, p. 56.)

ETIOLOGY

The various theories put forward in recent books upon the subject will be summed up as headings only:—

1. *The ulcer diathesis*,[5] said to be of two kinds, gastric and duodenal.[6]
2. *The acid factor*, said to be a cause of ulceration by Bolton[7] and Hurst,[8] but a result of it by other writers.
3. *The neurogenic factor* (Cushing, Rokitanski), sometimes doubtless a predisposing cause.
4. *The toxic factor* (Rosenow,[9] Wilkie[10]).
5. *The embolic factor*, of doubtful significance.
6. *The dietetic factor*.

The Dietetic Factor.—Much has been written about the first five factors, but the dietetic factor has received little attention, and in a recent massive work is dismissed in three lines as an "accessory factor". It is undeniable, however, that diet has a very large influence on the incidence of duodenal ulcer, and is more than an accessory as far as South India is concerned. The distribution of duodenal ulcer in Travancore (*Fig.* 179), where the part of that country with the densest population (the southern one-third) is that which has the lowest number of cases of ulcer, seems to point to a dietetic cause, as does the fact that the disease is far commoner in those parts of India where tapioca is eaten. It is an interesting fact that the Tinnevelly district of S. India, which used to be almost free from duodenal ulcer, has recently adopted the habit of eating tapioca-root, and is now producing a continually increasing number of cases of ulcer (*Fig.* 180).

Starting in 1927, Sir Robert McCarrison[11] made experiments on rats, feeding them on diets obtained from Madras and Travancore respectively.

1. Of rats fed for 675 days on Madrassi diet—11·1 per cent developed gastric ulcer.

2. Of rats fed for 675 days on Travancore diet—27·7 per cent developed gastric ulcer and 11·1 per cent developed a severe duodenitis.

3. Controls, well-fed rats—no cases of ulcer.

The ulcers in the rats which were fed on the Madrassi diet were in the synamous or proximal portion of the stomach; those with the Travancore diet developed ulcers in the distal or mucous portion of the stomach.

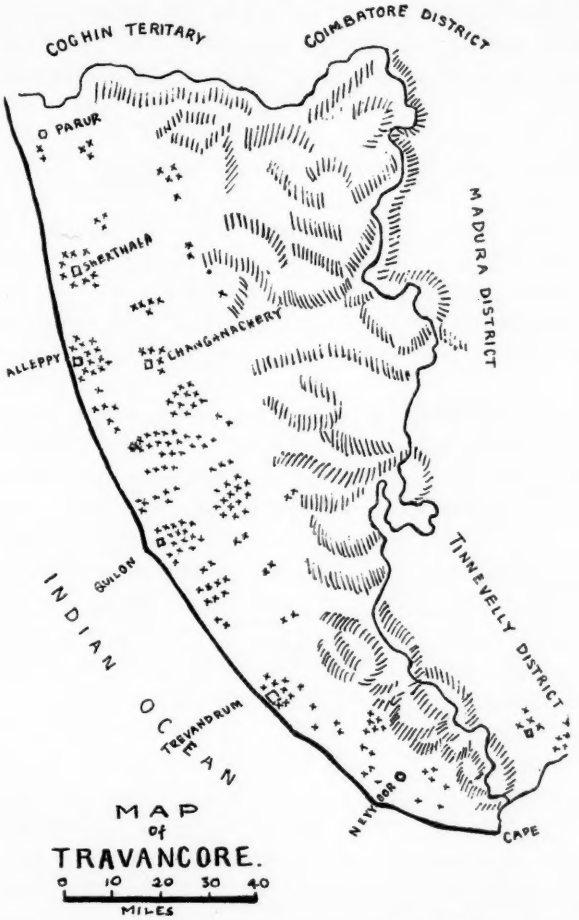


FIG. 179.—Map of Travancore, showing Neyyoor in the south; the crosses represent the areas from which peptic ulcer cases come.

This is in conformity with our clinical experience that gastric ulcer is relatively far more common in the Madras district than it is in Travancore, where duodenal ulcer outnumbers the gastric variety by 30 to 1.

In the rats fed with Travancore diet (tapioca, rice, chillies, pepper, and a little fish) the stomachs were dilated, the mucous membrane frequently congested, especially in the region of the pylorus, and some cases had shallow ulcers in this situation. The duodenum was often markedly congested, and there was

round-celled infiltration of many of the glandular organs, with occasional small hæmorrhages. The interesting thing about these observations is the fact that they correspond closely with the microscopic appearances we have seen in patients suffering from duodenal ulcer in Travancore. One is forced to the conclusion that the high incidence of duodenal ulcer in Travancore is due to the diet of the country, especially of the poorer classes, and that the ulcer itself is but a local manifestation of a general change in the tissues brought about by dietetic factors.[12]

What is the dietetic factor at fault, and how does it produce its effects?

a. The acid factor. The acidity, as obtained from fractional test-meals, of the South Indian, whether suffering from gastric or duodenal ulcer or not, is certainly slightly higher than what is considered normal in the west, except when he has gastritis, in which case acid is often low, and mucus content very high.

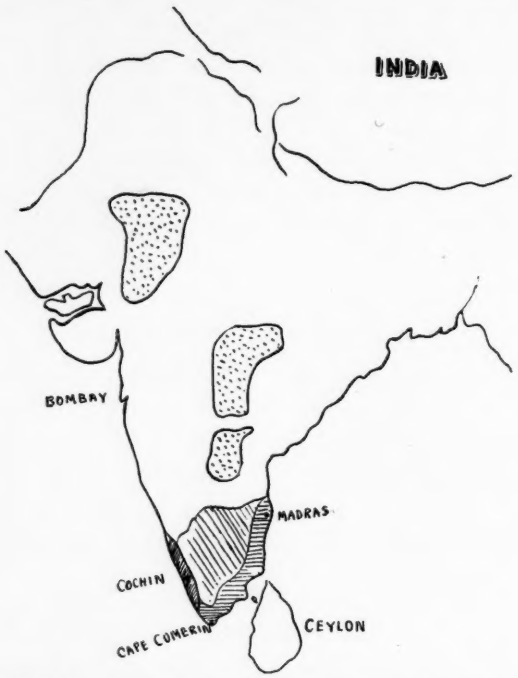


FIG. 180.—Map of India showing incidence of peptic ulcer. The deeply shaded portion represents Travancore and Cochin and South Malabar, where the diet is mainly tapioca root and rice, and the medium shading represents the Madura and Tinnevelly districts and East Madras Presidency, where rice is the staple food supplemented by gram and other grains. In this area peptic ulcer is common, but not as common as in Travancore. The oblique shading represents the remainder of Madras Presidency, where the diet is more varied and peptic ulcer less common. The stippled patches represent the wheat-growing areas, where duodenal ulcer is very rare.

b. The nervous factor and *c. The embolic factor* need not be considered in a country where half the time of most people is spent in watching the rice grow, and where such ulcers as do develop practically never bleed.

d. Trauma may, however, play some part. The highly spiced hot food, containing fibrous stringy vegetables, must inflict on even the most robust of stomachs some measure of trauma. But the general irritating nature of the South Indian diet is much the same in various parts, although the incidence of duodenal and gastric ulcer varies so much from one part to another; so we have to look further than trauma for the real effect of the diet as an ulcer-producing agent.

e. Vitamin deficiency. The great majority of our ulcer patients live on tapioca and rice, an almost exclusive carbohydrate diet with but little vitamin. Meat and fish are rarely taken; milk, eggs, and most fruits are luxuries used only by the well-to-do, who are not typically the class of case with peptic ulcer. Vitamins A, B, and C are especially deficient in the Travancore poor man's diet; and it has already been mentioned that this community has duodenal ulcer at a rate of incidence six hundred times greater than is the case in the Northern Punjab, where the people are said to have one of the best balanced diets in the world. In Travancore itself, peptic ulcer is infinitely more common in the central part of the State, where tapioca and rice form the staple diet, than in the southern portion, where a larger variety of vegetables, with rice and little or no tapioca, is eaten. One of us (I. M. O.) investigated the records of the State Troops of Travancore, who live in barracks with a well-controlled diet. In the last five years there have been only two (unproved) cases of duodenal ulcer among them; yet these same men come from villages where there is an incidence of duodenal ulcer of something like 1 per cent of the population. (In a hospital on the sea-coast, where we act as consulting surgeons, it has been noted that all their peptic ulcer cases come from the coolie population working in the fields inland; ulcers are very uncommon amongst the fisher folk who live by the sea and get a lot of fresh fish to eat.)

The function of vitamin A is "to maintain the functional integrity of the cells covering body surfaces, thereby preventing invasion of the organism by microbic agents" (McCarrison).

"One of the first demonstrable changes in avitaminosis is an alteration in the distribution of bacterial life within the lumen of the intestinal tract. The bacteria ingested by the mouth are not destroyed in the usual manner, but remain viable for many hours. . . . There is a gradual and progressive loss of the power of the body surface to control microbic life" (Lloyd Arnald).

These two extracts are sufficient to show that the high incidence of duodenal ulcer in Travancore is very likely due to vitamin—especially vitamin A—deficiency. This, by lowering the defences of the gastric mucosa, leads to an invasion of it by bacteria, and a chronic gastritis and duodenitis. The rupture of small abscesses in the lymph-follicles leads to ulcer formation, and the ulcers thus formed, if continually irritated by a highly spiced diet, refuse to heal but become chronic. This would seem to be the etiology of South India; and it is at least possible that vitamin deficiency is responsible for far more gastric and duodenal ulceration than has hitherto been supposed.

Chronic appendicitis—probably having a similar etiology—is very often associated with the duodenal ulceration; in nearly every case we operate upon in Neyyoor appendectomy is performed as a routine procedure; 73 per cent of all cases show some tenderness in the appendix region at the time of clinical examination.

EXAMINATION OF PATIENTS

The usual and obvious points, of history, etc., will not be mentioned. We now make the following examinations as a routine, not so much for diagnostic purposes as to indicate the line of treatment.

Test-meal.—Very high acidity, especially if this is maintained for some time, is an indication for gastrectomy of the Finsterer type; a large portion of the acid-secreting area of the stomach being thus removed.

Ordinary high acidity may be met with in a case in which the pylorus is stenosed, and in that case is no indication for gastrectomy as against gastro-jejunostomy, for we have found that a case of stenosis of the pylorus is best dealt with by gastro-jejunostomy. A low acidity may mean in some cases a chronic gastritis, of significance from its indication of a rigorous medical treatment during convalescence; a very low acidity (especially if coupled with a loss of appetite) being characteristic of malignancy.

X-ray Examination.—This is best carried out by the surgeon himself with a fluorescent screen, as the combination of vision with palpation gives him more information than a series of photographs taken by another person, except in certain cases in which the visibility of a crater and its persistence in successive radiographs are of importance for the diagnosis.

1. The size, position, and mobility of the stomach, and the activity of its peristaltic waves, may all be noticed, together with any irregularities it may possess.

2. The filling of the duodenal cap and its irregularities can be compared with any tenderness that is noted. At the same time the patient can be turned round, and notches in the shadow of the stomach or duodenum not visible in the antero-posterior position may be seen, and compared with local tenderness.

3. The time of emptying is important as a deciding factor in determining what operation should be done. Putting it broadly, we have found that the type of duodenal ulcer which is definitely tender on palpation but which is associated with rapid emptying of the stomach is best treated by a gastrectomy of the Finsterer type, especially if it is also associated with hyperchlorhydria; if treated by any other surgical method a jejunal or gastro-jejunal ulcer is very likely to be the sequel. If, however, there is delay in emptying the stomach (especially if that delay, with a liquid barium meal, is over six hours), the case will probably do well with a gastro-jejunostomy, unless acidity, as found by the fractional test meal, is very high.

TREATMENT

Under many circumstances, peptic ulcer is a medical condition. In early cases, and where circumstances permit, a course of medical treatment is indicated before resort to surgical measures.

But for the Indian villager—and nearly all of the cases considered in this article are of that type—medical treatment is out of the question, or was until the recent days of histidine. Certain articles, such as tapioca or chillies, can be forbidden; but there is no guarantee that he will ever obtain the articles necessary to balance his diet, or that he will submit to a rigid régime when he is once outside the walls of a hospital. To most Indian villagers, food means curry and rice, and the problem before us is to fit his stomach for the curry and rice which he will almost certainly put into it when he goes out of the hospital. It has therefore come about that in our clinic at Neyyoor we have almost universally resorted to surgery in the treatment of gastric and duodenal ulcer.

GASTRO-ENTEROSTOMY

At first, gastro-jejunostomy was our routine procedure, but as time goes on we have seen, in common with surgeons elsewhere (though often independently of them), that there are definite indications for other operations. Throughout our

experience, however, gastro-enterostomy has remained the operation of choice for cases where there is definite stenosis of the pylorus, with a healed or quiescent duodenal ulcer, and without any exceptionally marked hyperchlorhydria.

Causes of Failure after Gastro-enterostomy

Out of the two thousand and odd cases in which gastro-enterostomy has been done by us during the last ten years, we have had two main classes of failure.

The first class is those in which the *pylorus was not stenosed*; the ulcer was therefore not short-circuited, and food (often of an irritating nature) continued to pass the pylorus. In 5 per cent of all cases followed up, the persistence of the duodenal ulcer, and its irritation by food and gastric juice, led to continued pain and symptoms.

In these cases, we carried out a resection of the pyloric antrum—and sometimes of the duodenal ulcer itself—and thus converted the gastro-enterostomy into a Billroth II. The results of these cases were often very striking, a system of one-way traffic being thus introduced, and allowing the duodenal ulcer, if it was not excised, to heal. For some years we found that this type of secondary operation was very satisfactory, and in 1934 one of us (T. H. S.) reported that " a recurrence, or gastro-jejunal ulcer, has never been observed " in these cases. Since then, however, we have had to operate for gastro-jejunal ulcer on two patients who had previously had operations of the Billroth II type.* Out of 63 cases of this order, we have to report these two cases of gastro-jejunal ulcer, although the first 56 cases had been free from ulceration after a secondary Billroth II operation. The remedy for this class of failure is to perform a suitable gastrectomy for cases of duodenal ulcer with permeable pylorus, especially if there is also high acidity.

The second class of failure is seen in cases who are *indiscreet in their diet* at an early stage. It is this category which includes most of the cases of gastro-jejunal ulceration. Some of the less civilized of our patients have been known to escape from the hospital seven or ten days after their operation, and, going to a coffee-shop, to order a meal of curry and rice. Several times we have seen extremely early development of gastro-jejunal ulcer—in one case (No. 2300) in eleven days after the primary operation a well-marked ulcer was found at the anastomosis.

Other causes of trouble after gastro-enterostomy are as follows, and each of them bears an indication for the careful performance of the operation in the right way, rather than for the performance of some other operation instead.

1. Use of improper suture material. A certain Government Hospital in South India was in the habit, some years ago, of using a silk suture for the gastric mucosa; several cases whose gastro-enterostomy had been performed there came to us later with symptoms of gastro-jejunal ulcer. Of these, two were found to have ulceration (Nos. 1736 and 1809 in *Table III*); the remainder, some six or seven cases, had no ulcers, and recovered completely after we had removed the silk thread through a small incision in the stomach.

2. In a few cases gastro-jejunal ulcer was due apparently to a stoma placed

---

* *Note.*—Of the two cases of ulcer recurring after Billroth II operation, one was done by T. H. S. at Neyyoor; the other was done elsewhere. From our own cases we have only the one recurrence to note.

improperly. The stoma must reach the greater curvature, or it may allow an accumulation of food in the stomach in front of it, with consequent dragging on the stoma itself owing to the weight of the imperfectly emptied stomach.

3. If there is literally 'no loop' on the proximal end of the jejunum, the stomach may be held up in an unnatural position and the anastomosis dragged upon, with a resulting predisposition to ulcer in its neighbourhood.

4. Performance of gastro-enterostomy in a case without duodenal ulcer, but perhaps with chronic gastritis or high acidity, is inexcusable, and is only mentioned here for the sake of completeness, as being a cause of trouble later.

5. The stoma may be too large or too small. We have found the best average to be two and a half inches; if the stomach is very dilated, the stoma should be longer, as it will contract when the stomach contracts.

6. The loop for a gastro-enterostomy should not, as is well-known, be too long, or regurgitant vomiting may occur; it is best about two to three inches, but may be far longer in a Polya gastrectomy.

7. We have had two cases of recurrent ulcer owing to the gastro-enterostomy having been performed (at other hospitals) the wrong way round. Such a thing is by no means unknown in Britain.

Complications of Gastro-enterostomy

Acute Complications.—These are so well-known that we only wish to record here the routine treatments which we have found effective.

1. *Acute Dilatation of the Stomach.*—This is always heralded by a fairly sudden rise in pulse-rate. Any patient whose pulse rises rapidly has a stomach-tube passed at once, and the stomach washed out. In severe cases, the patient can be turned on his face and the tube left in position for some time. In addition to relieving acute dilatation, the stomach-tube may reveal a hæmorrhage or an excess of bile in the stomach, either of which may cause distress and a rise in pulse-rate.

2. *Hæmorrhage.*—The stomach is washed out, and 30 min. of adrenalin solution in an ounce of water is run in. Morphia and hæmoplastin are injected, and the patient laid flat.

All our cases of hæmorrhage in recent years have responded well to this treatment, and the only ones who have died (two) are those who have had an immediate second operation to stop the hæmorrhage. If such an operation is performed, the hæmorrhage is usually not seen, having stopped at the time of operation; and if the patient does not die as a result of the second operation, he may bleed again when reaction sets in. If transfusion is to do good, it must be done before the patient is too weak. It is usually unnecessary in these cases. If the stoma is made parallel to the main vessels in the stomach (i.e., transverse to its long axis) and if, when the mesocolon is sewn to the stomach wall the principal vessels in the neighbourhood are included in the five or six interrupted stitches required, fatal bleeding will hardly ever occur.

3. *Lung Complications.*—These are often avoided by giving pneumococcus immunogen *before* operation in all cases whose chest is not absolutely sound. If pneumonia develops, full doses of ammon. carb. and ipecac. are surprisingly well tolerated by a recently operated stomach, and save many patients from severe lung complications. Carbon dioxide inhalations soon after operation are a good prophylactic.

4. *Vomiting.*—Vomiting, besides that which is associated with dilatation of the stomach, is sometimes due to the unwonted *presence of bile in the stomach*, which has been for a long time unused to its presence owing to pyloric obstruction. Many of these cases are relieved by a stomach-tube and wash-out, followed by the administration of an acid mixture (15 min. of dilute sulphuric or hydrochloric acid in 2 oz. of water) from time to time. Sodium bicarbonate makes them worse, for it is the alkaline bile to which the stomach objects. Frequent drinks of water are almost invariably good, and the total withholding of fluids so often advocated is often very harmful.

If the vomiting is due to a *kink in the small intestine*, as is occasionally the case, a secondary operation may have to be performed, but this should not be undertaken unless it is clear that there is a definite obstruction—something more, that is, than a mere dilatation of the stomach. The vomiting of more than 3 pints of fluid in twenty-four hours is generally considered as an indication for secondary operation; the experienced surgeon will generally be guided by his clinical instinct to see that the vomiting is due to a definite obstruction, either from a kink or at the anastomosis.

Whether this obstruction is due to a kink in the small intestine or to œdema of the anastomosis, the treatment is the same—pass a nasal stomach-tube, and guide it beyond the obstructed place. Fluids, and the vomited gastric contents, can be introduced through this as required. Only if the original operation was technically wrong (e.g., long loops requiring entero-anastomosis) will more operative interference than the guiding of this tube be required.

Table I.—Results in 635 Duodenal Ulcer Cases Followed-up and Personally Examined, 1925–35

Length of Time after Operation	Excellent Result	Good Result	Pain as Complication	Incapacitated by Pain	Appendicular Pain or Adhesions	Total
5–10 years	19	7	5	1	–	32
2–5 years	44	3	14	6	–	67
1–2 years	24	5	6	2	–	37
Under 1 year*	24	5	15	10	–	54
			Duodenal Pain	Gastro-jejunal Ulcer		
Unclassified	345	42	24	28†	6	445
Totals ..	456	62	64	47	6	635
Percentages ..	71·5	10	10	7·5	1	100

* Notice the high proportion of painful complications during the first year, indicating that many of these cases settle down and cure themselves, some doubtless with alkalis or diet.
† 16 proved; 12 suspected.

Late Complications.—

1. *Adhesions causing Obstruction.*

2. *Intussusception of Small Intestine through the Anastomosis.*—These are rare complications, the possibility of which must be borne in mind, and the treatment for which is operation. In 2500 cases, we have had one case of intussusception and several of adhesions; but both are very rare, and by far the commonest complications are (3) and (4).

3. *Recurrence of Pain, and Non-healing of Original Duodenal Ulcer.*—This has already been dealt with under the heading of 'Treatment', and is nearly always satisfactorily treated by the simple operation of removing a segment of the stomach and converting the original operation into a Billroth II. A portion of the pyloric antrum should be left, as the mucin it secretes is apparently of beneficial effect in preventing subsequent ulceration. If, however, recurrent ulceration of the gastro-jejunal order does occur, which it did in one of our 63 cases, conditions will still allow a more radical resection of the stomach of the Finsterer type to be performed.

4. *Gastro-jejunal Ulcer.*—In 445 cases, all followed-up by a personal examination of the patients, this complication occurred in 28, of which 16 were proved by operation to have gastro-jejunal ulcer, and in 12 it was strongly suspected. Though various observers have reported percentages varying from one to twenty,[13] this figure of 6 per cent is about the average, and exactly agrees with Garnett Wright's estimate.[14]

In our own series of 2500 cases, we have dealt with 35 of our own gastro-enterostomy cases for gastro-jejunal ulceration. But some of our cases have no doubt been operated on elsewhere, and we, on the other hand, have operated on 46 cases whose first operation was done in other hospitals. Eighty cases of gastro-jejunal ulcer among 2500 of gastro-enterostomy is a percentage of only 3; whether the true figure is 3 or 6, in any case gastro-jejunal ulceration is the most common and the most feared of all complications of gastro-enterostomy.

ETIOLOGY OF GASTRO-JEJUNAL ULCER

Excluding such cases as are due to technical errors in the operation, mentioned above, gastro-jejunal ulceration is always due to a persistence of the conditions which caused the original ulceration. The consideration of the etiology is largely the consideration of the etiology of duodenal ulcer, which has already been done, and the principal factors in its production are:—

1. **Acidity.**—Cases with very high hyperchlorhydria are always prone to develop recurrent ulceration, some of them at a very early date. The fact that gastro-jejunal ulcer has never been seen after operations for gastric carcinoma (G. Wright[14]) is doubtless due simply to the fact that in carcinoma acidity is always low, and not to the explanations given by Wright in the paper quoted. I have seen several cases of undoubted gastro-jejunal ulceration cure themselves by frequent drinks of sodium bicarbonate over a long period. There is, therefore, little doubt that the principal cause of the ulcer is acidity, though it is not the only cause, for, in the Association of Surgeons' statistics (G. Wright, op. cit., p. 444) the acidity was found to be low in 20 per cent of cases, and high in only 60 per cent.

2. **Infective Foci.**—These are probably of minor importance, though if they happened to predispose to the original ulcer, and persist, they may also predispose to the recurrent ulceration.

3. **Diet.**—Cases have already been mentioned in which a gastro-jejunal ulcer has been produced within a few days of operation by an injudicious meal; in this case an irritation factor in the diet—and perhaps a straining of the anastomosis itself due to over-filling the stomach—is the immediate cause of the ulcer. But in cases in which a serious vitamin deficiency exists and was the cause of the original ulcer, owing to the considerations already mentioned near the beginning of this paper, the continuance of those same conditions and of the vitamin-deficient diet will always

predispose to a recurrence of ulceration; the natural defences of the gastric and intestinal mucosa are below par, owing to the deficiency of vitamins (especially A).

" The true etiology is unlikely to be known until we have solved that of duodenal and gastric ulcer. Whatever that cause, it is probably still active in the case of secondary ulcer " (*Brit. Jour. Surg.*, xxii, p. 444). In South India at any rate, this question of vitamin deficiency seems to be a fundamental cause of duodenal, and therefore also of gastro-jejunal, ulceration. It is our belief, however, that acidity is the most important of these three causes.

PREVENTION OF GASTRO-JEJUNAL ULCER

The prevention of gastro-jejunal ulcer is threefold :—

1. *A suitable operation* must be done in the first place. Gastro-enterostomy in cases of high acidity with no pyloric stenosis is an unsuitable operation.

2. In other cases, in which gastro-enterostomy *is* suitable, *it must be done properly*, with the lower end of the anastomosis near the greater curvature of the stomach, and with catgut suture in both layers. The loop should be 2 or 3 in. long, and the anastomosis itself about 3 in. except in very dilated stomachs. No knots should be inside the gut, as is usually advised in text-books, but should always be outside the serous coat. No suture should pass through the interval between stomach and intestine, or infection will be drained from the lumen of the gut into the space where healing is to take place. All stitches involving the mucosa should definitely pass through all coats of the stomach, the suture being started and finished *outside* the organ. So-called redundant mucosa should *not* be removed, as it helps to protect the seromuscular layers from the action of gastric juice. The chief blood-vessels around the anastomosis should be tied by the stitches fixing the mesocolon to the stomach, which should never be within half an inch of the anastomosis itself.

3. *Adequate post-operative treatment* by alkalis and suitable diet must be observed. If recurrence of the ulcer is staved off for a few months after the operation, it is far less likely to occur. Moreover, undoubtedly a few definite gastro-jejunal ulcers heal up with medical treatment.

If all these points are observed, gastro-jejunal ulcer, as well as other complications, will become less frequent. The first point mentioned, however, namely, the performance of a suitable operation, needs to be expanded. After our experience in Neyyoor we have been forced more and more to the conclusion that for all cases for which a gastro-enterostomy is contra-indicated by pyloric permeability or hyperacidity, a gastrectomy of the Finsterer type is the ideal operation.

GASTRECTOMY

The functions of a gastrectomy are ideally :—

1. To lower gastric acidity. All gastric operations do this for a short time, and Polya or Billroth II may do so for some months. But the ideal gastrectomy from this point of view will remove a large proportion of the acid-secreting portion of the stomach, and thus effect an actual substantial diminution of gastric acidity.

2. To create a one-way traffic system, denying the food all possible access to the ulcer.

3. To promote healing of the ulcer either by the actual removal of it, or by leaving it in a condition in which it will heal.

The leaving behind of a portion of the pyloric end of the stomach (*Fig.* 181, A, 4) will result in a free secretion of mucus in this region, with which the ulcer is surrounded. In practice, we have found less trouble and pain after this operation than after a simple gastro-enterostomy. Incidentally, this mucus will be of benefit to the intestine at the region of the anastomosis, in decreasing the likelihood of recurrent ulcer. Also, it is easier to divide the stomach a little distance away from the pylorus rather than close to it. Several of our deaths from gastrectomy were due to the great difficulty in closing a pylorus near the sphincter; a couple of inches away from it there is no difficulty whatever.

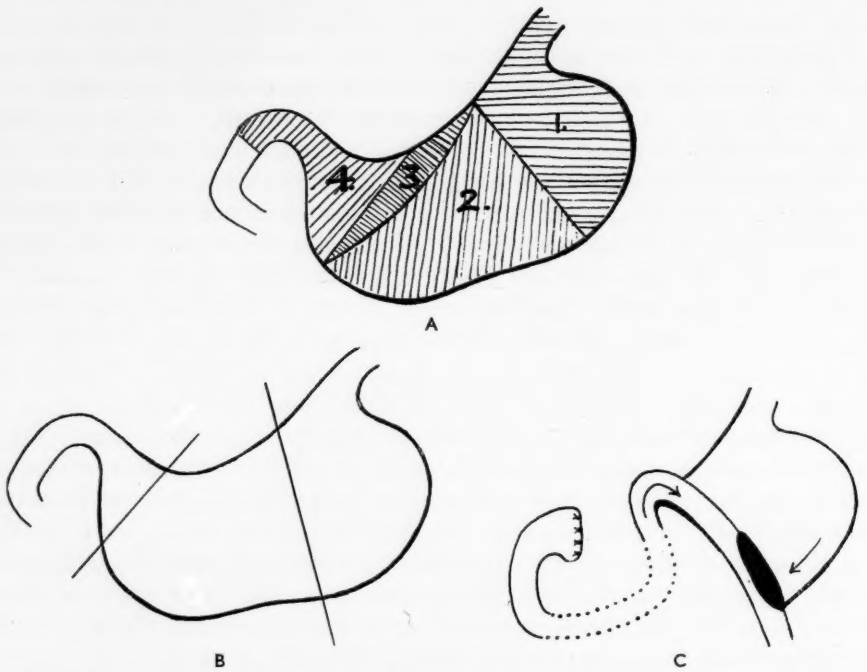


FIG. 181.—A, Shows the physiological divisions of the stomach: 1, Cardiac portion; 2, Fundus; 3, 'Gastric pathway'; 4, Pyloric antrum. B, Shows the amount of stomach removed in the Finsterer gastrectomy. C, The re-formation of the stomach after gastrectomy.

We have entirely given up all thought of removing duodenal or pyloric ulcers, for the same reason. They invariably heal if one-way traffic is established by a gastrectomy; and every surgeon knows that excision of a duodenal ulcer can be one of the most precarious and difficult of all abdominal operations.

Some surgeons still consider that so severe an operation as gastrectomy should not be performed for duodenal ulcer. The answer is two-fold: first, that in proper hands gastrectomy is not an operation with high mortality—as a primary operation for duodenal ulcer we have done it 81 times with but 2 deaths; second, that under certain conditions gastro-enterostomy carries a higher risk.

It will be seen from *Table II* that the greater part of the 6·5 per cent mortality of gastrectomy is when that operation is performed for gastric or gastro-jejunal ulceration. A gastrectomy performed on a stomach which is not itself ulcerated, adherent, or inflamed, is not, if conducted properly, a dangerous operation. Surely an operation with a 2 or 3 per cent risk is preferable to the alternative anastomosis

with an operative risk of 1·5 per cent and an ulcer-recurrence rate of 6 per cent, to say nothing of the other 10 per cent of cases who have trouble of some sort after gastro-enterostomy.

Table II.—GASTRECTOMIES DONE AT NEYYOOR, 1925–35

DISEASE	NUMBER OF OPERATIONS	DEATHS	PERCENTAGE
Duodenal ulcer	81	2	1·3
Gastric ulcer	46	5	11·0
Gastric carcinoma ..	18	1	5·5
Gastro-jejunal ulcer ..	57	5	9·0
Total	202	13	6·5

The operation now performed at Neyyoor for reduction of acidity is therefore the high gastrectomy associated with Finsterer, and its effects are :—

1. Permanent reduction of acidity by the removal of a large area of the fundus.*
2. Exclusion of the ulcer from irritation by food and promotion of its healing by the mucus secreted in the pyloric antrum.
3. No risk of leakage from an imperfectly closed duodenum.
4. No risk of regurgitation of food into the duodenal blind end, owing to the vertical position of the stoma.

It must be stressed at this point that this high gastrectomy operation is not to be a routine treatment for all duodenal ulcers. Where there is stenosis, or where there is low or normal acidity, gastro-enterostomy remains the operation of choice.

Where, however, there is very high acidity and rapid emptying of the stomach, the high Finsterer gastrectomy is indicated. One of us (I. M. O.) has recently done 30 cases of these operations without a death, in cases which included 9 gastro-jejunal ulcers and several poor operative risks. In this series there were no cases of bilious vomiting, and the convalescence has been remarkably smooth—better, in fact, than after the average gastro-enterostomy. It is too early to report late results from this type of operation, as it is only recently that we have been driven by all the foregoing conclusions to perform it. All that we have heard about are in a satisfactory condition, except for one case of anæmia, in a woman who had a gastric ulcer, with anæmia and low acidity at the time of operation. If the acidity is high at the time of operation, and reduced by operation to normal or thereabouts, the danger of anæmia is almost nil.

THE TREATMENT OF GASTRO-JEJUNAL ULCER

Here we are up against an ulcer caused presumably by the same causes as produced the original duodenal ulcer—acidity, low vitamin A diet, irritating food-stuffs, sepsis—with the possible addition of faulty technique in the original operation.

The particulars of 72 cases treated at Neyyoor are set out in *Table III.*

* *Note.*—We have proved by test-meal records that the reduction in acidity varies with the amount of stomach removed. In the few cases in which one of us (I. M. O.) has carried out test-meals several months after the operation, it is found that the reduction in acidity is maintained.

Table III.—GASTRO-JEJUNAL ULCERS TREATED AT NEYYOOR, 1925–35

Note.—PGE = Posterior gastro-enterostomy; AGE = Anterior gastro-enterostomy; GJ = Gastro-jejunal ulcer; G = Gastric ulcer; D = Duodenal ulcer; J = Jejunal ulcer; C = Gastrocolic fistula; B = Billroth; P = Polya; F = Finsterer high gastrectomy; Y = Anastomosis (jejuno-jejunal); E = Excision of ulcer; A = Anterior.

No. or Date	Original Operation	Interval	Complication	Second Operation	Remarks
446	PGE	2½ yr.	GJ	E	Suspected to have a recurrence of the ulcer when seen 8 years later
320	PGE	3 yr.	GJ	E	Satisfactory
308	PGE	2 yr.	GJ	P	Pain later due to kink, relieved by entero-anastomosis
557	PGE	9 m.	GJ	E	Satisfactory
520	PGE	3 yr.	GJ	B II	Satisfactory
522	B I	1 yr.	GJ	B II	Secondary ulcer in jejunum, excised 1 month later. Satisfactory result and rapid gain in weight
768	PGE	?	GJ	E + Y	Satisfactory—not followed-up
781	PGE	3½ yr.	GJ	E + Y	Continuance of pain
882	PGE	1 yr.	GJ	E	Died
888	PGE	5 m.	GJ	E	Satisfactory
717	PGE	4 yr.	GJ	E	Unsatisfactory: continued pain
893	PGE	1 yr.	GJ	E	Immediate result satisfactory
1929·6	PGE	3 yr.	GJ	E	Immediate result satisfactory
1929·9	PGE	1½ yr.	GJ	E	Immediate result satisfactory
1927·11	PGE	2 yr.	GJ	E + AGE in Y	Immediate result satisfactory
1929·3	PGE	4 yr.	G + D	P	Immediate result satisfactory
1325	PGE	2 yr.	GJ + C	AGE + Y	Satisfactory 1 year later
1350	PGE	1 yr.	GJ	B II	Improved
1932·10	PGE	2 yr.	GJ	P + Y	Satisfactory
1932·10	PGE	1 m.	GJ	P + Y	Satisfactory
1028	PGE	2 yr.	GJ	E	Satisfactory
1036	PGE	1 m.	GJ	P + Y	Satisfactory
1126	PGE	1 m.	GJ	E	Unsatisfactory: recurrence of ulcer suspected
1130	PGE	6 m.	GJ + G	E	Satisfactory
1174	PGE	4 m.	GJ	E	Recurrence of GJ ulcer, relieved 2½ yr. later by B II
1190	PGE	4 yr.	GJ	E	Recurrence of GJ ulcer, relieved 1½ yr. later by B II
1209	PGE	2 yr.	GJ	E	Satisfactory
1261	PGE	3 yr.	GJ	B II	Satisfactory
1344	PGE	3 yr.	GJ + C	E	Stormy convalescence, but now satisfactory
1359	PGE	1½ yr.	GJ	P + Y	Satisfactory
1388	PGE	2 yr.	GJ	E + Y	Recurrence of GJ ulcer, apparently cured medically
1454	PGE	2 yr.	2 GJ's	P	Died—subphrenic abscess
1457	PGE	6 m.	GJ + C	P	Satisfactory
1518	PGE	4 yr.	GJ	B II	
1589	PGE	4 yr.	GJ + C	B II	Satisfactory
1590	PGE	6 yr.	GJ + C	E	Died
1620	PGE	6 m.	3 G's	B II	Satisfactory
1646	PGE	3 yr.	G	B II	Satisfactory
1654	PGE	8 yr.	J	E etc.	Satisfactory after PGE and AGE + anastomosis
1688	PGE	4 yr.	G	P	Died
1692	PGE	1 yr.	GJ + C	P + Y	Satisfactory
1736	PGE	1½ yr.	GJ	B II	Satisfactory—silk thread in PGE suture found
1758	PGE	1½ yr.	GJ	B II	Satisfactory

[Continued on next page

Table III.—GASTRO-JEJUNAL ULCERS TREATED AT NEYYOOR, 1925–35, *continued*

No. or Date	Original Operation	Interval	Complication	Second Operation	Remarks
1762	PGE	2½ yr.	GJ	P + Y	Satisfactory: PGE found done the wrong way round
1773	PGE	5 yr.	GJ	P + Y	Died
1809	PGE	6 m.	GJ	B II	Satisfactory: silk thread as No. 1736
1891	PGE	4 yr.	GJ	B II	Re-operated 5 m. later for intussusception of small intestine. Recovery
1901	PGE	6 yr.	GJ + J	P + Y	Satisfactory
1903	PGE	7 m.	GJ	E	Bad position of original operation corrected. Hence no gastrectomy
1926	PGE	3 yr.	J + C	E + B II	Satisfactory
1930	PGE	6 yr.	G	B II	Satisfactory
1933	PGE	3 yr.	J	P + Y	Satisfactory
1965	PGE	7 yr.	J + C	E + B II	Satisfactory
1969	PGE	8 yr.	GJ	B II	Satisfactory
2005	PGE	3 yr.	GJ	E	Satisfactory, but pain and tenderness over stoma; X rays show no abnormality
2028	PGE	4 yr.	GJ	P + Y	Satisfactory
2073	PGE	1 m.	GJ	B II	Satisfactory: slight discomfort daily
2082	PGE	9 yr.	GJ	P	Satisfactory
2152	PGE	6 yr.	GJ	B II	Satisfactory
2226	PGE	1 m.	GJ	E	Satisfactory
2230	PGE	5 m.	GJ	B II	Satisfactory except for slight pain over stoma 1 yr. later
2233	PGE	1 yr.	G	P	Satisfactory
2285	PGE	1 yr.	GJ	E + B II	Satisfactory
2293	PGE	7 yr.	GJ	E	Died from leakage
2300	PGE	11 days	GJ	P + Y	Died
2313	PGE	4 yr.	GJ	P + Y	Satisfactory
2321	PGE	?	GJ	E + B II	Satisfactory
2344	PGE	4 yr.	GJ + J	P	Good at first, but died 2 m. later
2334	PGE	8 yr.	2 D's	B II	Satisfactory
2372	PGE	6 m.	GJ	F	Satisfactory
2382	PGE	?	GJ	P	Died of cerebral œdema
2383	PGE	?	GJ + C	P + Y	Satisfactory
2476	PGE	12 yr.	GJ	P + Y	Satisfactory

Analysis.—Out of 2500 operations for gastric, duodenal, and jejunal ulcers:—

Operations for Gastro-jejunal Ulcers	No. of Cases	Deaths	Recurrence	Unsatisfactory
Excision of ulcer and re-forming stoma	24	4 (16·6%)	8 (33·3%)	–
Billroth II	28	–	1	2
Polya	20	5 (25%)	1 (5%)	1
Totals	72	9 (12·5%)	10 (13·8%)	3 (4%)

Since these statistics were compiled, one of us (I. M. O.) has done high (Finsterer type) gastrectomy in 9 cases of gastro-jejunal ulcer with no deaths, making a total of 81 cases, 9 deaths (11·1 per cent).

Two of these cases, as mentioned elsewhere, were recurrences of ulcer after a low gastrectomy (B II). Of the 72 cases tabulated, 35 had had the primary operation performed at Neyyoor; the remainder were from other surgeons.

From this table it will be seen :—

1. That the operation of excision of the ulcer and re-formation of a gastro-enterostomy has been given up as producing unsatisfactory results. It is difficult to do, and leaves the mechanics of the digestive apparatus in the same condition as they were when the recurrent ulcer was produced, and is manifestly unsound.

2. That the Billroth II operation is less risky than one of the Polya type. This is doubtless partly due to the fact that the smaller the ulcer, the more likely is it possible to do the Billroth II operation, whereas if there is much induration, etc., a Billroth II will be impossible.

FIG. 182.—Method of re-formation of intestine, and performance of gastrectomy operation by method which does not involve a Y-anastomosis.

3. That the average mortality of these cases was over 10 per cent.

4. That since the high gastrectomy operation has been done, this mortality has been reduced.

It is sufficient to say that it is obvious that the best thing that can be done for a gastro-jejunal ulcer is that which is most likely to prevent its recurrence in the first place. As in the case of duodenal ulcer, we are driven to the concluson that an excision of the ulcer followed by a high Finsterer gastrectomy is the ideal treatment. For the cases which get gastro-jejunal ulcers are just those with high acidity, etc., which ought many of them to have been treated originally by means of a high gastrectomy. In dealing with many of these cases one is up against a major surgical problem, and one that may tax the skill of any operator.

Adherence to the colon may complicate matters, but so long as there is no fistula it need not be serious. The base of a gastro-jejunal ulcer may be left on the outside of a colon, and as the anastomosis, together with the fundus of the stomach, is going

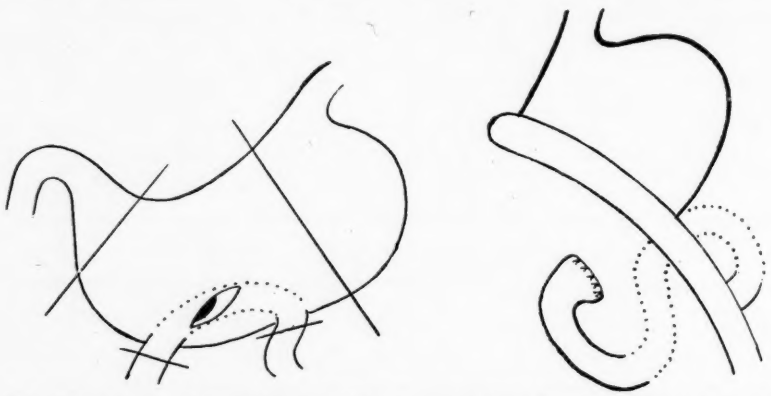


FIG. 183.—The amount of stomach removed in the gastrectomy for gastro-jejunal ulcer and the method of re-formation of the stomach.

to be excised in any case, mutilation of the anastomosis or its area does not matter. The ulcer-base on the colon is then covered by omentum and should cause no trouble.

Having decided that a high gastrectomy is necessary, there are two ways in which it may be done :—

1. The jejunum may be joined end to end, and a Finsterer gastrectomy performed (*Fig.* 182). This is the method of choice, as it gives a chance for the bile and mucus from the duodenum to get into the stomach and help to reduce its acidity and to protect the mucosa of the jejunum near the anastomosis.

2. The gastrectomy may be performed in Y, as in *Fig.* 183. We have done this on several occasions, but theoretically it is not so sound as the other method.

The essential feature of the operation in either case is the removal of a large part of the acid-secreting portion of the stomach, and the preservation of the pyloric antrum; and although it is radical, it has not yet shown itself to have a high mortality, and compares favourably in this respect with all the other methods of treatment. We hope to report further in a few years' time on the late results of this type of operation compared with those of other methods.

CONCLUSIONS

1. In South India, lack of vitamin A and other dietetic factors seem to be the principal cause of duodenal ulceration, and it is possible that these factors have been insufficiently considered as causative of duodenal ulcer in the Western countries.

2. Gastro-enterostomy is the operation of choice for duodenal ulcer where there is stenosis.

3. High gastrectomy, without excision of the pyloric antrum, is the operation of choice for gastric and gastro-jejunal ulcer, and for duodenal ulcer with high acidity and rapid emptying.

REFERENCES

[1] KONJETZNY, *Arch. f. klin. Chir.*, 1924, cxxix, 139.
[2] PUHL, *Med. Klin.*, 1927, xxiii, 986, 1063.
[3] CARSWELL, *Atlas of Pathol. Anat.*, 1838, reproduced in Hurst & Stewart, *Gastric and Duodenal Ulcer*, 1929. Oxford Med. Pub.
[4] FABER, *Lancet*, 1927, ii, 901.
[5] HURST, *Guy's Hosp. Rep.*, 1921, lxxi, 450.
[6] BARCLAY, *The Alimentary Tract*, 1915. London.
[7] BOLTON, *Ulcer of the Stomach*, 1913. London.
[8] HURST AND STEWART, *Gastric and Duodenal Ulcer*, 1929, 59, 60. Oxford.
[9] ROSENOW, *K. Inf. dio.*, 1923, xxxiii, 248.
[10] MAINGOT, *Post-Graduate Surgery*, i, 184.
[11] MCCARRISON, *Ind. Jour. Med. Research*, 1931, and *Brit. Med. Jour.*, 1931, i, 970.
[12] *See also* HARRIS, *Jour. Amer. Med. Assoc.*
[13] MAINGOT, *Op. cit.*, 404.
[14] GARNETT WRIGHT, *Brit. Jour. Surg.*, 1935, xxii, 435.
[15] MORLEY, *Ibid.*, 1928, xvi, 247.
[16] GORDON TAYLOR, *Ibid.*, 1929, xvi, 659.
[17] LAKE, *Lancet*, 1928, ii, 268.

CONGENITAL DISC-SHAPED LATERAL MENISCUS WITH SNAPPING KNEE*

By D. STEWART MIDDLETON

HON. SURGEON, CHURCH OF SCOTLAND DEACONESS HOSPITAL, EDINBURGH

THE occasional persistence of the embryonic disc shape of the lateral meniscus of the knee-joint has been known to anatomists for many years. The first dissecting-room specimen to be described was that by Young of Glasgow in 1889, and since then twelve examples have been placed on record.

Several authors have described the development of the cartilage fully and pointed out the relationship between its embryonic disc shape and the disc-shaped meniscus seen in the adult. Attention has also been directed to the appearance of a disc- or ring-shaped meniscus in certain lower animals such as monkeys and some lizards, though it is doubtful whether these comparative studies have much bearing on the condition in the human being. It would be a work of supererogation to detail this work, as it has been so ably summarized by Jaroschy of Prague, whose work on congenital disc cartilage will always remain the classical study of this interesting subject.

The occurrence of a striking snapping noise in the knee-joint on movement, along with a visible separation of the femur and tibia, has been noted on many occasions in European literature. European journals before 1914 are strewn with examples of such cases. The etiology was found puzzling owing to the absence of previous trauma, and the occasional occurrence of a similar snap in the knee-joints of children very soon after birth. These cases were not submitted to operation, and the snapping was as a rule attributed to a ' subluxation ' owing to laxity of the capsule and ligaments of the joint. From the clear-cut clinical histories accompanying these cases, however, there can be no doubt that they were examples of snapping knee, due to congenital disc-shaped meniscus.

It was in 1910 that the association of a disc-shaped lateral meniscus with snapping knee was first pointed out by Kroiss of Innsbruck, who removed from a snapping knee a torn lateral meniscus and appreciated the importance of the fact that the meniscus, though torn, was so much wider than normal as to come into the class of what is now recognized as a disc-shaped meniscus. Since 1928, starting with one case by Bristow and two by Schulz, a number of examples have been described, and longer articles have appeared by Finder, Bell-Jones, Jaroschy, and Timbrell Fisher. I have already alluded to the importance of the very complete historical, clinical, and anatomical study of Jaroschy. Up to the present date 30 fully documented examples of snapping knee from this cause have appeared in the literature, along with 19 more which are mentioned as having been encountered without any clinical or anatomical detail being given. The fact, however, is that

* From the Department of Surgery, University of Edinburgh.

49 cases of disc-shaped meniscus causing snapping knee have been treated by operation since 1910, and 48 of these have been published since 1928.

Timbrell Fisher in a recent article draws a parallel between this condition and cysts of the meniscus. He points out that these cysts were at one time looked upon as rarities, but that as knowledge of the condition became diffused they became progressively more common and are now met with so frequently as not to call for comment. Fisher believes with justice that the same course will be followed by disc menisci, and that their apparent comparative rarity is mainly attributable to the fact that they are not sufficiently often recognized.

It cannot be gainsaid that, though all orthopædists and those interested in the surgery of the knee-joint are conversant with the condition, and most of them have operated on a varying number of cases, this type of snapping knee, as an entity, is still largely unknown to the general surgeon.

During the past two years I have met with 4 examples of snapping knee of this type, and have also had the opportunity of examining one dissecting-room specimen. A survey of these cases has led me to certain conclusions regarding the mode of production of the snap, a subject which has been largely ignored by previous authors.

A chronological list of references to previously recorded cases is appended at the end of this paper.

CASE REPORTS

Case 1.—G. G., male, aged 11 years.

HISTORY.—Six weeks before admission to The Church of Scotland Deaconess Hospital, the patient was swinging his legs while sitting in a chair, when he felt a sudden acute pain over the outer side of the right knee. Before this, he had had no trouble with the joint. Afterwards the movements of the knee were painful for a few days, but no locking occurred. He rested in bed for a few days and when he started to go about again he noticed a definite 'clicking' noise in the knee. This clicking was at times associated with a little swelling of the joint and vague pain and instability.

ON EXAMINATION.—There was a trace of effusion into the right knee. No wasting of the quadriceps was present. On movement of the joint, a marked click or snapping sensation could be elicited at points just short of full flexion and of full extension. There was no history of knee trouble in parents or relatives, and X-ray examination was negative.

OPERATION, Nov. 11, 1933.—The joint was opened in front of and behind the fibular collateral ligament by a lateral Timbrell Fisher incision convex distally. The lateral meniscus was seen to be very broad, filling the whole lateral compartment of the joint, and it was split longitudinally. The meniscus was removed in several pieces and the specimen was unfortunately destroyed.

Convalescence was uneventful, though delayed by a slight post-operative effusion. Re-examination of the patient in November, 1935, showed the knee to be perfectly stable, and function appeared to be completely normal.

Case 2.—A. N., male, aged 13 years. (*Fig.* 184.)

HISTORY.—According to the patient and to his parents, the right knee had been the seat of a "cracking" sound "all his life." At times he had suffered from slight discomfort and a little effusion into the joint, but it had never seriously interfered with his activities. There was no history of injury to the joint.

ON EXAMINATION.—There was no visible abnormality in the joint and no wasting of the quadriceps was present. On flexing the joint, at a point some 20° to 30° short of full flexion there was a slight 'check' in the smooth movement of the joint; the femoral and tibial condyles appeared to separate from each other momentarily, and as they fell together again an audible and palpable 'clunking' noise was evident. Extension from the fully flexed

position was perfectly smooth up to a point some 20° short of full extension, when the 'clunking' noise repeated itself. The snapping was completely painless. There was no history of any knee troubles in the family, and the left knee appeared normal on clinical examination. X-ray examination showed no obvious abnormality.

OPERATION, Jan. 25, 1934.—At operation in The Church of Scotland Deaconess Hospital the knee-joint was opened by a wide lateral Timbrell Fisher incision, reflecting the patella medially in order to get a free view of the offending cartilage during movement of the joint. A drawing was made of the joint at this stage (*Fig.* 184). A wide cartilage was found covering the whole lateral condyle of the tibia, save for a small area nearly half an inch in diameter close to the intercondylar ridge. In front of this bare area, the anterior horn of the broad cartilage swelled out to blend widely with the intercondylar structures, while the posterior

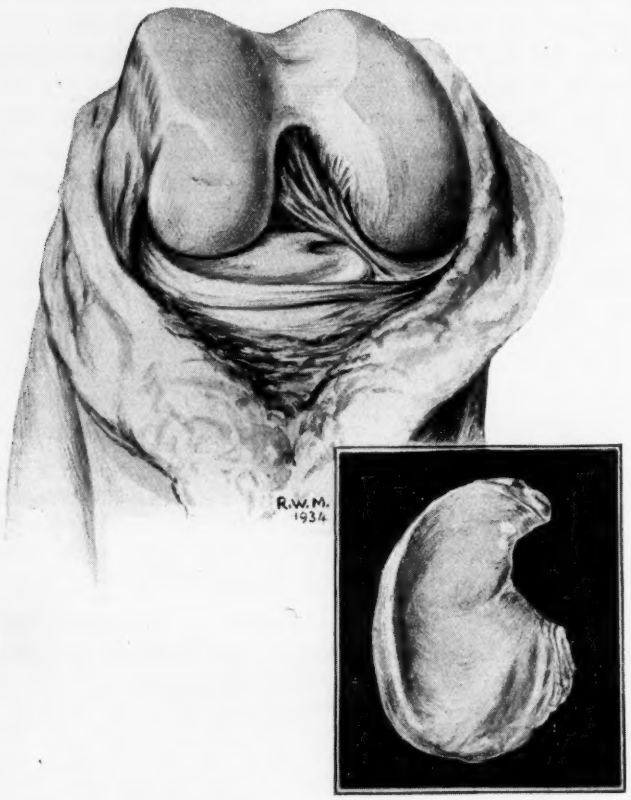


FIG. 184.—*Case* 2. A drawing of the knee-joint made at the time of operation. The broad disc-shaped lateral meniscus can be seen, and the inset shows the meniscus after removal, with a definite oblique ridge upon the upper surface.

horn, though somewhat wide, was much more normal in shape. The upper surface of the meniscus presented a well-marked ridge running obliquely laterally and forward from the notch on the medial border. This ridge divided the femoral surface into two portions or facets—an anterior one which articulated with the femoral condyle in extension and a posterior one articulating with the condyle in full flexion.

On flexing and extending the joint the snap could be reproduced. Starting with the joint in full flexion, and the meniscus largely visible in front of the condyle of the femur, which was in contact with the posterior facet on the meniscus, on extension the meniscus was seen to become gradually more and more bunched up in front of the femoral condyle as the articular surface of the latter rolled forwards on to the ridge. At a point 20° short of full extension, the femoral condyle could be seen to ride up on the ridge, causing the

visible separation of the femoral and tibial condyles which has been stressed so frequently by previous authors. The femoral condyle then slipped suddenly over the crest of the ridge, and sank down with an audible 'clunk' or 'thud' into the anterior facet on the meniscus in front of the ridge. On flexion the process was reversed, the femur riding over the ridge into the posterior facet short of full flexion.

The meniscus was removed entire and the joint closed.

Convalescence was uninterrupted, and on examination in December, 1935, all signs of snapping had disappeared and the function of the joint appeared to be normal in all respects.

Case 3.—I. T., male, aged 13 years. (*Fig.* 185.)

HISTORY.—At the age of four this patient was confined to bed for a period of two years with a tuberculous spine, making a good recovery. On getting up and resuming walking, a snapping noise was noticed in his left knee on movement. The noise was always present and never varied. There was no history of knee trouble in other members of the family.

ON EXAMINATION.—A 'clunking' noise and sensation, similar in all respects to that described in the previous case, could be elicited on movement of the joint at points just short of full flexion and of full extension of the joint. There was no swelling of the joint and no quadriceps wasting.

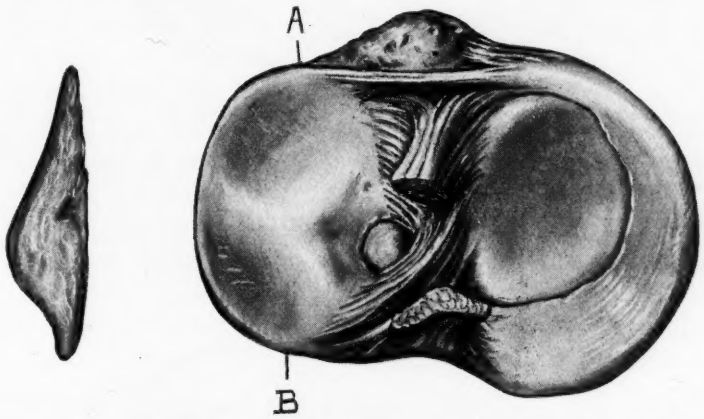


FIG. 185.—*Case* 3. The drawing shows the position occupied at operation by the lateral meniscus, with its broad disc shape and the well-marked oblique ridge over which the femur rode to produce the snapping. The height of the ridge is well brought out in the inset, which shows the longitudinal section of the meniscus from A to B.

OPERATION, April 18, 1935.—At operation in The Church of Scotland Deaconess Hospital the left knee-joint was opened by a lateral Timbrell Fisher incision, reflecting the patella inwards. The lateral meniscus was observed to have a roughly quadrilateral shape with a small notch on its medial margin. It formed a complete disc covering the lateral condyle of the tibia entirely save for a small area about a quarter of an inch in diameter close to the intercondylar area. Both anterior and posterior horns of the meniscus were broad and thick and blended widely with the structures attached to the intercondylar area. The femoral surface of the meniscus was marked by a well-formed oblique ridge running laterally and forwards from the region of the small intercornual notch. This ridge divided the meniscus into anterior and posterior facets, and on movement of the joint it was observed that the femoral condyle rode over the ridge at points just short of full extension and full flexion, occupying the anterior facet in full extension and the posterior one on full flexion. The meniscus was removed entire, and the inset in *Fig.* 185 shows the well-marked ridge on longitudinal section of the meniscus.

Convalescence was uneventful, and examination of the patient in December, 1935, showed that the snap had completely disappeared and the knee-joint was normal in every way.

Case 4.—F. D., female, aged 18 years. (*Fig.* 186.)

HISTORY.—Two years previously the patient, who had been in employment in a rubber works, had noticed the gradual commencement of a snapping noise in the left knee. She

is sure that there was never any injury and that she had never had any pain in the knee whatsoever. Apart from the snapping, which annoyed her slightly, she had no trouble with her knee, and actually came to hospital on account of a sprained wrist, merely mentioning the condition of her knee incidentally.

ON EXAMINATION.—The knee appeared to be perfectly normal, and there was no wasting of the quadriceps or local tenderness. On movement of the joint a typical 'clunking' noise

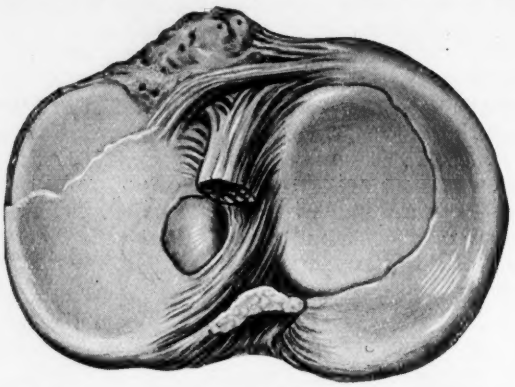


FIG. 186.—*Case* 4. A drawing to show the relationship of the lateral meniscus as seen at operation. The meniscus is disc-shaped, and separated round the periphery of its anterior horn.

was elicited a few degrees short of full flexion and extension, the syndrome being indistinguishable from that described in the previous cases. X-ray examination was negative.

OPERATION, Aug. 16, 1934.—At operation in The Church of Scotland Deaconess Hospital the left knee was opened by a lateral Timbrell Fisher incision, reflecting the patella medially. The lateral meniscus was seen to be of the typical disc shape, with a broad anterior horn

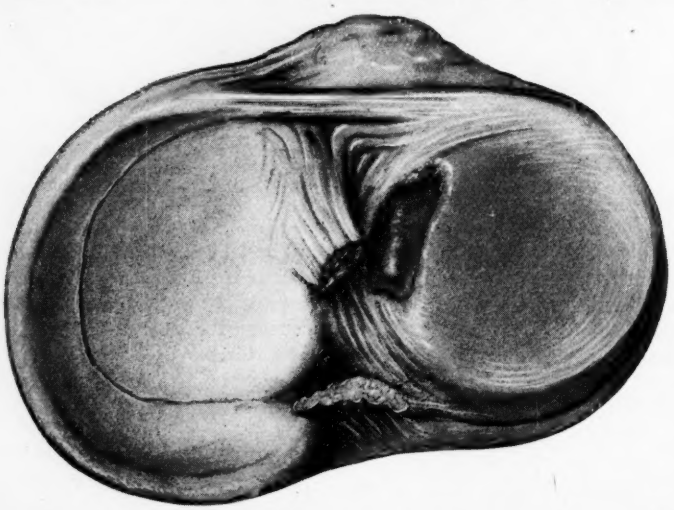


FIG. 187.—Anatomical specimen, by courtesy of Dr. G. J. Boyd. No history available, but the abnormality was discovered in the dissecting room. The lateral meniscus is disc-shaped, and presents a smooth concave upper surface. There is no reason to suppose that such a meniscus had caused snapping during life.

blending with the intercondylar structures. Between the two cornua, there was a small notch about a quarter of an inch across through which the upper aspect of the lateral tibial condyle could be seen. The periphery of the anterior horn of the meniscus was separated from its attachments. There was no ridge present on the upper aspect of the meniscus, this surface being a smooth concavity.

On movement, the femoral condyle was observed to occupy the concavity of the meniscus in the position of flexion, while as the position of extension was approached the separated anterior horn slipped backwards behind the condyle, which then lay in direct contact with the upper aspect of the tibia. The reverse occurred at a point near full flexion, the meniscus suddenly jumping forwards again between the femur and tibia. The ' clunking ' noise was caused by the sudden movement of the femoral condyle backwards or forwards over the thick free anterior edge of the meniscus.

Anatomical Specimen.—By courtesy of Dr. G. J. Boyd. (*Fig.* 187.)

This specimen was encountered in the dissecting rooms of the University of Leeds. No history is forthcoming. The specimen consisted of the upper portion of the tibia and fibula of an adult with the menisci in situ. The medial meniscus is normal. The lateral meniscus forms an almost complete disc, covering the upper aspect of the lateral tibial condyle completely save for a small elongated area close to the intercondylar area. The upper aspect of the meniscus is smooth and concave, there being no ridge present. The specimen is somewhat hard, as befits one emanating from the dissecting room, but there is nothing to suggest that the meniscus was unduly mobile during life. A slight degree of separation of the anterior horn has evidently been the result of dissection. *Fig.* 187 shows the cartilage, the whole appearance of which suggests that it represents a disc-shaped meniscus which has remained symptomless throughout life.

DISCUSSION

A snapping noise in the outer part of the knee-joint has long been associated with lesions of the lateral meniscus, and forms indeed a common picture in tears of that structure. The classical case of non-traumatic snapping knee due to congenital disc-shaped lateral meniscus may simulate a torn lateral meniscus very closely, and it should be realized at once that almost half of the cases of disc meniscus on record are examples of tearing of a malformed disc, and also that abnormal wideness or complete disc formation is present in a large proportion of the ordinary traumatic lesions of the lateral meniscus (18 per cent according to Bell-Jones). In other words, the disc meniscus is more liable to injury than the normal one.

In cases of non-traumatic snapping knee from disc meniscus, snapping may be noted at or soon after birth, but frequently appears later in life without any obvious pre-existing injury. The cases in extreme infancy are unusual, but I am conscious of having in the past seen two cases of snapping knee within the first two or three months of life where the symptom had been noted by the parents soon after birth. It is important to note that when snapping occurs at this early age, and indeed even in later life, it may pass off entirely after having been present for a considerable time.

In such a developmental abnormality as this it is almost certain that inheritance plays a part in its transmission. In one case recorded by Bell-Jones, indeed, the mother of the affected child showed similar symptoms, and though the state of the parental knee-joint was not investigated by operation there can be little doubt that she presented a disc meniscus. There was no family history in my personal cases, but having regard to the fact that a large proportion of disc menisci are probably symptomless throughout life and that the total of recorded cases where a history of any sort is available is small, it is not surprising that only one case with a history of familial transmission is on record. It would be interesting to accept the case described by von Stackelberg in 1927 of snapping knee, with associated deformities, including partial absence of the tibia, as due to a disc

cartilage, but Jaroschy writing in 1935 hesitates to do so. Certainly the illustrations in a later article by von Stackelberg (1929), where dissections of the knee are shown, do not warrant its inclusion as an example of the type of snapping knee under consideration.

Clinical Features.—These, when present, consist of a painless snapping sensation on movement of the affected joint. Where only one knee is the seat of snapping, the disc formation may be bilateral. Snapping does not seem to be the cause of much disability in non-traumatic cases, though complaints of occasional vague pain and slight synovial effusion may be met with.

On examination, the configuration of the joint is normal, and there is no muscular wasting in the quadriceps extensor apparatus in the absence of superadded injury to the meniscus.

The typical ' snap ' takes place at the extremes of movement, occurring usually at points about 20° short of full flexion and of full extension of the joint. When the snap occurs, a momentary check in the smooth movement of the joint is seen, and the tibia and femur appear to separate slightly on the outer side of the joint and then come together again. At the same time it is said that a slight protuberance appears between them which is thought to be the meniscus itself. This check in movement and separation of the lateral condyles is momentary, and is accompanied by a palpable and audible noise. The noise has been described as a ' snap ', ' click ', ' thud ', or ' clunk ', the last being, perhaps, the most descriptive. Finder believes that radiographic examination shows an aplasia of the lateral condyle of the tibia and a widening of the lateral joint space, but I have been unable to convince myself of the diagnostic value of this appearance in my own cases.

The above description of the clinical features of snapping knee appears to be fairly constant for non-traumatic cases. Where, however, a previously symptomless disc meniscus suffers from a superadded tear, symptoms may be caused which are indistinguishable from the non-traumatic case, as in my first case, or the less obvious snapping of a torn lateral meniscus may appear. Not infrequently snapping may be completely absent in such traumatic cases, and a diagnosis may rest upon the history of injury along with quadriceps wasting and finger-point tenderness over the torn meniscus.

Anatomy of the Disc Meniscus.—This varies comparatively little from case to case. In some examples the general form is circular and the upper surface is concave, as in the dissecting-room specimen which I have described (*see Fig.* 187). More commonly the disc is almost quadrilateral in shape with a small notch on its medial margin. Here one gets the impression that not only is the body of the meniscus broad, but that both cornua are greatly broadened and have wide attachments to the intercondylar structures, as in *Fig.* 185. Finally, there is what may be called the ' comma-shaped ' meniscus seen in *Fig.* 184, where the body and the anterior cornu of the meniscus are broadened while the posterior horn remains almost within normal limits. It is quite likely that a similar condition affecting the posterior horn only may occur, though I have not seen a case figured in the literature. The circular, quadrilateral, and anterior-horn ' comma-shaped ' menisci are, however, all represented in the illustrations of other authors.

Etiology of the Snapping Noise.—The mere presence of a disc meniscus does not cause symptoms, but symptoms requiring removal of the structure may be brought about in several ways.

1. *Trauma.*—The disc-shaped meniscus is undoubtedly more liable to injury than the normal lateral meniscus, as explained above.

2. *The Ridged Disc.*—In this class, to which *Cases* 2 and 3 belong, a ridge develops on the upper aspect of the meniscus with a concave facet in front of and behind it. In flexion of the joint the condyle of the femur lies behind the ridge, and on extension taking place between the femur and the meniscus the latter structure becomes bunched up in front of the advancing condyle until late in the movement. At a point about 20° short of full extension, however, the femur mounts the ridge, rides over the crest, and comes to occupy the anterior facet, producing the classical signs as it does so. A similar but reversed process takes place during flexion of the joint, the snap occurring about 20° short of full flexion (*Fig.* 188). A similar backward and forward movement to this has been noted in cases described by Schulz and Jaroschy, though the importance of the ridge does

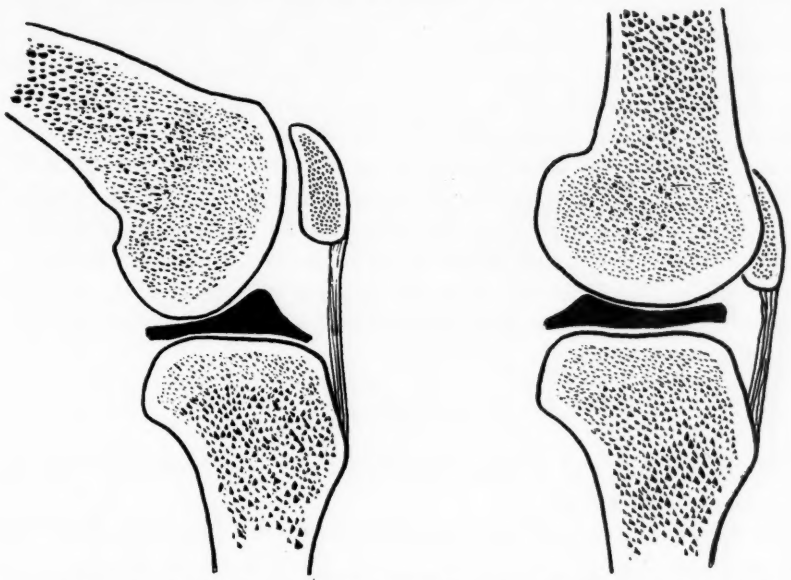


FIG. 188.—Diagram to show the way in which a ridged meniscus causes snapping, and the relationship of the femoral condyle to the meniscus and ridge in flexion and in extension.

not appear to have been appreciated. In another case of Jaroschy's the meniscus is described as passing backwards in flexion and forwards in extension, a reversal of the usual movement.

3. *Abnormal Mobility of the Disc.*—The normal lateral meniscus moves backwards and forwards fairly freely on flexion and extension of the knee-joint, but eventually the range of movement of the disc meniscus may become so great and the anterior or posterior attachments of the meniscus so stretched that the whole meniscus may slip backwards and forwards in flexion and extension, causing snapping. In *Case* 4 the anterior attachments had become separated entirely in the absence of any trauma. Here in flexion the femoral condyle articulated with the upper aspect of the disc in the normal fashion, while during extension the condyle rolled and slipped over the free anterior margin with a thudding sound, the disc meniscus disappearing behind the condyle, which then came to articulate directly with the tibia.

There are cases on record where the posterior horn has become separated, and it is probable that in these cases the process was reversed.

Treatment.—In most cases of persistent snapping due to disc menisci the offending meniscus should be removed. In young children operation may be delayed, as the snapping not infrequently disappears spontaneously. In older children this is less likely to happen, and there can be no doubt that prolonged snapping with the slight effusion and synovial reddening which accompany it may eventually, if untreated, lead to the development of osteo-arthritis.

The meniscus is easily removed through the ordinary short incision in common use for traumatic lesions of the menisci in this country. The long patella-reflecting incision was utilized in my cases for the sole purpose of being able to watch the cartilage easily on movement and to work out the mechanism of the snapping sound.

It will be remembered that on full flexion the snapping disc jumps forwards into the anterior portion of the joint, and remains there until a point not far short of full extension, when it jumps backwards. During the application of a tourniquet, therefore, the meniscus will be in its posterior position, and if the knee is then merely allowed to flex to a right angle over the end of the table in the usual manner, unnecessary difficulty will be experienced at operation. In *Case* 4, for instance, the meniscus would have been found lying entirely behind the lateral femoral condyle. The last manœuvre after applying the tourniquet in these cases should be to carry out full flexion of the joint and thereby snap the meniscus into its anterior position. The knee can then be allowed to extend from the fully flexed position to semiflexion, and the cartilage will be found in its most accessible position when the joint is opened.

SUMMARY

1. Four new cases and a new dissecting-room specimen of congenital lateral disc meniscus are described.

2. The manner in which the snapping knee of congenital disc meniscus is produced is discussed.

BIBLIOGRAPHY

(chronologically arranged)

Cases Described in Dissecting or Post-mortem Room.—

1889—YOUNG, R. B., in Cleland, Mackay, and Young's *Memoirs and Memoranda in Anatomy*, 179. London and Edinburgh: Williams and Norgate. (Three specimens.)

1895—HIGGINS, H., *Jour. Anat. and Physiol.*, 1895, xxix, 390. (Two specimens.)

1904—FICK, R., in Bardeleben's *Handbuch der Anatomie des Menschen*, ii, No. 1, 358. (One specimen.)

1911—POIRIER, P., *Traité d'Anatomie humaine*, 1911, i, 692. Paris. (Two specimens.)

1924—FISHER, A. G. TIMBRELL, *Internal Derangements of the Knee-joint, their Pathology and Treatment by Modern Methods*, 2nd ed., 1924, 12. London: H. K. Lewis & Co. (One specimen.)

1928—LANGER, M., *Anat. Anzeiger*, 1928, xliv, 409. (Two specimens.)

1931—FRÜND, Verein niederrein-Westfal. Chir. 1931, see *Zentralb. f. Chir.*, 1931, lviii, 2391. (This article refers to the condition, but does not describe a case. A personal communication regarding the case in question appears, however, in Jaroschy.)

1932—DUNCAN, D., *Anat. Rec.*, 1932, liii, 305. (One bilateral specimen from a negro.)

Clinical Cases Verified by Operation, with Detailed Description.—

1910—KROISS, F., *Beitr. z. klin. Chir.*, 1910, lxvi, 598. (One case with superadded tear.)
1928—BRISTOW, W. R., *Proc. Roy. Soc. Med.*, 1928, xxi, 241. (One case.)
1928—SCHULZ, A., *Arch. f. orthop. u. unfall Chir.*, 1928, xxvi, 315. (Two cases, one traumatic.)
1932—ELLIS, V. H., *Lancet*, 1932, i, 1359. (Two cases.)
1932—ROCYN-JONES, A., *Proc. Roy. Soc. Med.*, 1932, xxv, 395. (One case.)
1933—LLOYD, E. I., *Lancet*, 1933, i, 525. (Two cases.)
1934—FINDER, J. G., *Jour. Bone and Joint Surg.*, 1934, xvi, 804. (Three cases, one by personal communication from Timbrell Fisher; one traumatic.)
1935—BELL-JONES, E., *Liverpool Med.-Chir. Jour.*, 1935, xliii, 78. (Collected fourteen new cases, eight of which were traumatic.)
1935—JAROSCHY, W., *Beitr. z. klin. Chir.*, 1935, clxi, 139. (Complete survey of literature, comparative anatomy, and three new cases, one of which was traumatic.)
1936—FISHER, A. G. TIMBRELL, *Brit. Med. Jour.*, 1936, i, 688. (Two cases, one previously described by Finder; one of these was traumatic.)

Clinical Cases Mentioned without Details.—

1930—FAIRBANK, H. A. T., *Proc. Roy. Soc. Med.*, 1930, xxiii, 1001, also *Brit. Med. Jour.*, 1930, i, 581. (Has operated on two cases.)
1930—JONES, R. WATSON, *Proc. Roy. Soc. Med.*, 1930, xxiii, 1588. (Has seen two cases.)
1934—DUNN, NAUGHTON, *Lancet*, 1934, i, 1267. (Has seen eight cases.)
1936—MCFARLAND, *Brit. Med. Jour.*, 1936, i, 819. (Has seen nine cases.)

Other Articles Referred to.—

1927—STACKELBERG, VON, *Deut. Zeits. f. Chir.*, 1927, cciii, 204.
1929—STACKELBERG, VON, *Ibid.*, 1929, ccxxi, 414. (Both these articles deal with a case of snapping knee in a five-months infant. In the second the pathological findings at post-mortem are shown, and do not warrant its inclusion as a case of disc cartilage.)

SOME EXAMPLES OF DISEASE OF THE VERTEBRAL COLUMN FOUND IN SKELETONS OF ANCIENT EGYPT

A CONTRIBUTION TO PALÆOPATHOLOGY

By L. R. SHORE, Cambridge

In this paper it is proposed to offer descriptions of a few specimens which show different types of disease in the vertebral column. All the specimens to be described are contained in a collection of vertebral columns at Cambridge derived from excavations at Hierakonpolis, and are attributed to the Predynastic Epoch. The material includes about 4100 vertebræ, being the remains of 274 columns. The degree of damage or loss that has occurred will be appreciated from the statement that no more than eight columns are complete or capable of being reconstructed.

The term 'palæopathology' was coined by Sir Armand Ruffer to indicate that branch of scientific inquiry which is concerned with the pathological processes which affected the human body in the remote past. Obviously the material available for such inquiry is mainly limited to bones, except where exceptional circumstances and a high standard of the arts and crafts, as in Egypt, extended the field for research. Ruffer himself described the lesions of bilharzia, of arterial disease, and even of variola in tissues derived from mummies, in the collection of writings which have been published under the title *Studies in the Palæopathology of Egypt*. From dolls, bas-reliefs, and other sculptures Ruffer has given an account of dwarfs and deformities from which fairly exact diagnosis can be made. The same book contains a paper on "Arthritis Deformans and Spondylitis in Ancient Egypt". Having had a field for observation that ranged from archaic Nubians through Predynastic, Dynastic, and Ptolemaic Egyptians to the Greek and Roman periods and even to the Copts of early Christian times, Ruffer[1] formed an opinion that may well be stated in his own words:—

> The pathological anatomy of spondylitis did not vary during this period of eight thousand years. Further, it is clear that geographical distribution did not influence the course or incidence of the disease, since specimens from Lower Egypt, Upper Egypt, and Nubia showed that the frequency, nature, and severity of the lesions were unaffected by varying climatic conditions.

The present paper is written in the hope of presenting some matter of interest though based upon nothing but dried and macerated bones. Probably no specimen will be described which might not be found in a modern skeleton in a modern museum of pathology. It is the presence of similar lesions in the vertebral columns of ancient Egyptians that constitutes their chief claim to interest.

All the specimens to be described have one feature in common, namely, ankylosis of certain members of the vertebral column. Closer examination of the specimens shows the presence of different causative processes bringing about this common effect.

It may perhaps be of service to recall in brief terms the more important mechanisms by which the units of the vertebral column are united in the natural state. Anterior to the spinal canal, the bodies of the vertebræ, by their cartilage-covered upper and lower surfaces, make contacts with the intervertebral discs, structures which possess central nuclei of a highly expansive nature restrained by layers of tough fibrous tissue. Short ligaments extending from vertebral body to vertebral body lie outside the intervertebral discs. Enclosing the vertebral bodies and the tissues between them around their circuit for the whole length of the column lies a fibrous envelope of which the well-known anterior and posterior common ligaments are specialized thickenings. Posterior to the spinal canal, the dorsal arches, by contact of each with its upper and lower neighbour, make a series of dorsal diarthrodial joints. In addition, the dorsal arches are connected by a series of powerful interlaminar ligaments (ligamenta subflava) and by the interspinous ligaments.

It follows, therefore, that when the perivertebral fibrous sheath is ossified a layer of new bone will be found to hide the normal superficial texture of the vertebral bodies. If sufficiently extensive, this new bone surrounds the site of the intervertebral disc, which is represented in a macerated specimen by an intervertebral space. When the deeper ligaments, those of no more than intervertebral length, are ossified, the normal appearance of the vertebral bodies is not lost at the bases of the osteophytes which are marginal in their place of origin.

The capsular ligaments of the dorsal intervertebral joints in an ossified state may enclose a joint either patent or obliterated by bony invasion; it is only by section that it can be determined which condition obtains.

Ossified interlaminar ligaments are recognized by their anatomical position.

SPECIMEN I.—ANKYLOSIS OF THE SECOND AND THIRD LUMBAR VERTEBRÆ

(*Figs.* 189, 190)

The anterior view in *Fig.* 189 shows that the normal superficial texture of the vertebral bodies is lost. A superficial sheet of new bone, of a texture smoother than normal though porous here and there, somewhat raised and, as it were, *appliqué*, envelops the vertebral bodies and encloses the intervertebral space. It seems, therefore, that new bone has been laid down in the perivertebral fibrous sheath. On the right side this bony sheet is complete as far back as the intervertebral or neural foramen; on the left side and in front it is partly deficient and the normal surface of a vertebral body may be seen. A marked prominence over the intervertebral union projects towards the right side and makes the specimen asymmetrical.

The dorsal arches are not united: no ossific process has invaded the interlaminar ligaments, the capsular ligaments of the dorsal intervertebral joints, or the joint cavities themselves. *Fig.* 190 is a photograph of a section made in a coronal plane and traversing the prominence on the right side. This prominence is shown to be a bridge of cancellous bone; the intervertebral space is not invaded; the lower (3rd lumbar) vertebral body is somewhat wedge-shaped, with the narrow edge towards the right.

It is certain that ankylosis is of long standing, for marrow spaces have penetrated the bony bridge of union from end to end. The texture of both bones is less compact than normal, and is certainly disorganized in the neighbourhood of the connecting bridge. Degeneration of the 3rd lumbar body is shown in its partial collapse into a wedge shape.

The agent which brought about the degenerative process probably was a microbic invasion—almost certainly blood-borne; otherwise it is difficult to account for the degenerative process being so generalized through the two vertebræ. One of the effects of this agent has been an intense stimulation towards new bone formation in the fibrous envelope of the two vertebræ.

FIG. 189.

FIG. 190.

FIG. 189.—*Specimen I.* Ankylosis of the 2nd and 3rd lumbar vertebræ. The specimen is viewed from the front. A sheet of superficial bone, of texture smoother than normal, covers the two vertebral bodies and the intervertebral space except for a gap on the left front. A break in the superficial sheet extends from this gap towards the right; this break was the result of a mischance in handling the specimen, but it follows the intervertebral space. The new superficial bone corresponds to the superficial fibrous sheath of the vertebral column.

FIG. 190.—*Specimen I.* This photograph shows the appearance of a coronal section through the ankylosed 2nd and 3rd lumbar vertebræ. The intervertebral space is patent; the lower vertebral body is somewhat wedge-shaped, with the thin edge towards the right, and is also slightly hollowed. The texture of both bones is less compact than is normal. Cancellous bone is continuous in the bony bridge which connects the two vertebral bodies and corresponds to the prominence on the right side seen in the last figure.

The intervertebral space, so far from being reduced, is rather enlarged, for the lower vertebral body is slightly hollowed on its upper surface. This suggests that the normally expansive intervertebral disc met with decreasing resistance as the bone became softened by disease. Also it is shown that the intervertebral disc retained its turgor and therefore was not diseased. This conclusion goes far to negative the infecting organism as *Bacillus typhosus*, which, being generally credited with a predilection for the tissues of the intervertebral discs, leads to their early collapse in typhoid infections of the spine.

Except for arthritis this specimen goes far to reproduce the picture of 'spondylitis ossificans ligamentosa' described by Lawford Knaggs,[2] showing, as it does, superficial ossification of ligaments, preservation of the intervertebral space, and rarefaction of bone. Lawford Knaggs insists that these features, with arthritis, represent a vertebral manifestation of an infective or 'rheumatoid' process in the body elsewhere. Perhaps we are viewing a specimen which attained spontaneous cure, possibly after formation of the envelope of new bone which answered as a splint and secured immobility of the inflamed parts.

SPECIMENS II, III, AND IV.—ANKYLOSIS OF THE SECOND AND THIRD THORACIC, SIXTH AND SEVENTH THORACIC, AND THIRD AND FOURTH LUMBAR VERTEBRÆ

(*Figs.* 191, 192)

In one vertebral column bony ankylosis has occurred between three pairs of vertebræ, the 2nd and 3rd thoracic, the 6th and 7th thoracic, and the 3rd and 4th lumbar.

All three specimens are extraordinarily light to handle and very fragile; they have been so considerably damaged that certain of the superficial details are uncertain. The left lateral appearances of these three pairs of vertebræ are shown in *Fig.* 191.

The mechanism of union seems to be much the same for each pair of vertebræ. The dorsal arches are firmly united by bone and so also are the vertebral bodies. While it is easy to define the mechanism of union of the former, it is not at all easy to state by what means the vertebral bodies are joined.

In these specimens there is no obvious sheet of superficial bone such as was seen in *Specimen I*; it seems rather that vertebral body has formed direct union with vertebral body, because the vertebral bodies have an almost normal superficial texture.

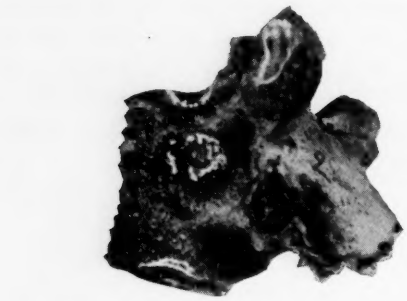
Specimen II—2nd and 3rd Thoracic Vertebræ.—The surfaces of the two vertebral bodies show light superficial striation as is found normally. The position of the intervertebral joint is quite apparent, being marked by a ridge which bears upon it a transverse line with here and there a short linear gap. Part of the same gap is to be seen on both sides in the area for articulation of the head of the 3rd rib. This articular area, and the intervertebral interval, are shown in *Fig.* 191, ringed in white chalk upon the specimen before it was photographed.

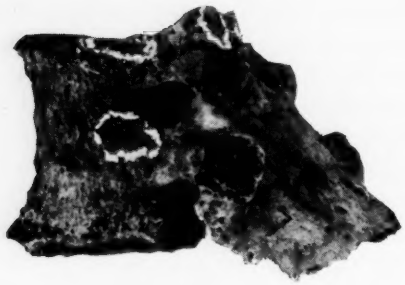
From the side view it is evident that the vertical depth of the 2nd thoracic vertebra is much less than that of the 3rd, and the section in *Fig.* 192 shows the same difference. That compression and distortion of the same vertebra have taken place is shown by two further findings in *Fig.* 191: first, the upper vertebral body bulges while the other is slightly hollowed; secondly, the 3rd costo-central joint is out of alinement with the 2nd and 4th, being situated in a more posterior plane.

Specimen III—6th and 7th Thoracic Vertebræ.—These two vertebræ are joined into a curve of slight anterior concavity, corresponding to the normal curve of the thoracic column. The surface of the two vertebral bodies is striated, scarcely different from the normal, but is continued below into a flange which projects about 2 mm.

The position of the intervertebral joint is indicated on the right side by a line about 4 mm. long, and on both sides by gaps in the areas for articulation with the

heads of the 7th ribs. The vertebral bodies are not hollowed, therefore no ridge marks the union, and the incidence of disease upon these two vertebræ does not seem to have been unequal. The transverse processes have been broken off, and so it is impossible to report on the condition of the costo-transverse joints. The three costo-central and dorsal intervertebral joints above and below the place of ankylosis show no signs of disease.





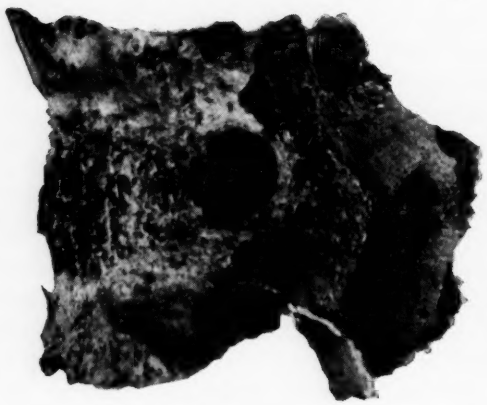
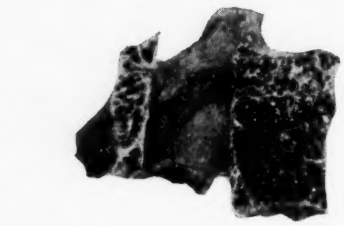
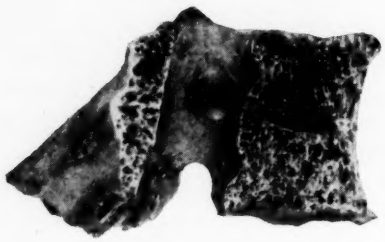


FIG. 191.





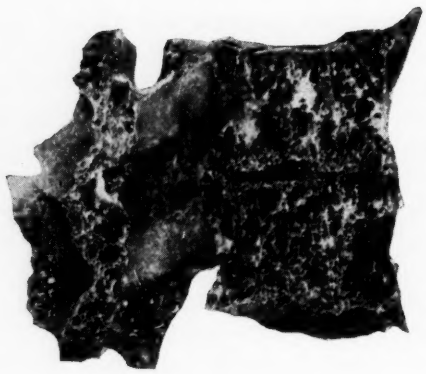


FIG. 192.

Specimen IV—3rd and 4th Lumbar Vertebræ.—*Fig.* 191 shows that these two vertebræ have been considerably damaged; the transverse processes have been lost, and the ridge that covered the intervertebral union has been largely broken away.

In this specimen, near the upper and lower margins, the surface of the bone is smoother and less obviously striated than in the others, also it is somewhat bulky and punctured with small foramina. This appearance, together with its continuation into flanges of bone which project from each of the upper and lower edges of the specimen, suggests some ossification in superficial ligaments.

Both vertebral bodies are hollowed to a very considerable degree, and it seems that a conspicuous ridge, now broken away for the most part, must have marked their place of union. The dorsal end of this ridge partly occludes the intervertebral foramen. Where the intervertebral union has been exposed by superficial breakage no intervertebral space is to be seen—only bone of a very porous texture.

Fig. 192 shows photographs of the three pairs of vertebræ after section. In each specimen the plane of the cut through the vertebral bodies is true sagittal, but that through the dorsal arches passes to the right of the middle line.

FIG. 191.—*Specimens II, III, and IV.* A photograph of three pairs of ankylosed vertebræ derived from the same column and viewed from the left side. *a*, Th. 2–3: *b*, Th. 6–7; *c*, L. 3–4.

a. Th. 2–3 shows the articular surfaces, picked out in white chalk, for the heads of three ribs and for the 2nd costo-transverse joint; the 3rd costo-transverse joint has been lost with the 3rd transverse process. The 3rd costo-central joint shows a trace of the intervertebral space in the form of a narrow gap. This joint is in a plane posterior to that for the heads of the 2nd and 4th ribs, thus showing evidence of distortion. The 2nd vertebral body bulges somewhat, while the 3rd retains its normal slight hollow. The union of the two vertebral bodies is marked by a slight ridge, which bears traces of a line upon it. The general surface of the vertebral bodies is almost normal.

b. Th. 6–7. These two vertebræ are united in a curve which is nearly normal for this part of the vertebral column. The position of the intervertebral union is clearest in the area for articulation with the head of the 7th rib. No ridge marks the union, and the vertebral bodies are not distorted. Both transverse processes with their costo-transverse joints have been lost, but the costo-central and the dorsal joints above and below appear to be normal.

c. L. 3–4. These two vertebræ have been much damaged, having lost both transverse processes and the surface of the ridge that marked the union between the two bodies. Both vertebral bodies are hollowed, and the ridge that marked the union at the dorsal end considerably obstructs the intervertebral foramen. Where the ridge of union has been broken no intervertebral space is to be seen, only very porous bone. At the upper and the lower margins of the specimen flanges of bone project. These flanges are of smoother texture, and pierced by a few small foramina. The dorsal intervertebral joints above and below are normal.

FIG. 192.—*Specimens II, III, and IV.* This photograph shows the three pairs of ankylosed vertebræ after section. The plane of the section through the vertebral bodies is true sagittal; that through the dorsal arches traverses the sites of the dorsal intervertebral joints. In all these specimens the dorsal joints have been completely obliterated, and cancellous bone occupies the former joint sites. Union of the dorsal arches is also effected by ossification of the interspinous ligaments, best seen in Th. 6–7, and by ossification of the interlaminar ligaments, which is best seen in the upper and the lower specimens. The texture of the bones both in the vertebral bodies and in the dorsal arches is greatly rarefied. Compression of the 2nd thoracic body, previously remarked, is seen again. The intervertebral spaces are progressiveiy invaded from the periphery, most conspicuously in the lowest, and least in the highest of the three specimens.

The figure shows that in each specimen the vertebral bodies are joined across the intervertebral space—very extensively in the lowest, less so in the middle, and least in the uppermost pair.

Bony invasion of the intervertebral space probably commenced circumferentially and spread inwards into the intervertebral discs. In the 3rd and 4th lumbar vertebræ, the site of the most advanced and therefore the oldest pathological change, even the central parts of the intervertebral space have been invaded by new bone.

In each specimen the dorsal intervertebral joints are completely obliterated, and cancellous bone, i.e., marrow, is continuous from dorsal arch to dorsal arch across the former site of the joint. Not only the bone of the dorsal arches, but also the new bone which occupies the joint sites, is very porous. It is perhaps surprising that the costal joints, so far as they have been preserved, are normal.

The sections of the vertebral bodies show a texture which is very porous or spongy. It may be a matter of wonder that they are not hollow on their upper and lower opposed surfaces in response to the expansive pressure exercised by the intervertebral discs. The explanation probably lies in the loss of this expansive quality of the discs from disease, of which most ample evidence lies in their invasion by bone, the presumed effect of an inflammatory process spread from the vertebral bodies. That pressure was exerted by the intervertebral discs at some stage is shown by the section of the 2nd and 3rd thoracic vertebræ, which shows at once slight hollowing and the least degree of invasion of the disc. It follows, therefore, that softening of the vertebral bodies preceded bony invasion of the intervertebral discs.

The following are the outstanding features of *Specimens II, III, and IV*: ossification of the ligaments of the dorsal arches; arthritis of the dorsal intervertebral joints, evidenced by obliteration of the joint cavities; invasion of the intervertebral discs; and rarefaction of bone. Perhaps the processes which led to these results were something as follows.

Invading microbes, almost certainly blood-borne, settled in the bone of the vertebral bodies and of the dorsal arches, and in the dorsal intervertebral joints.

In the joints microbic activity led to destruction of cartilages and their substitution by granulation tissue. Fibrous adhesions prepared the way for osteogenetic cells to invade the former joint cavities from both of the articulating bones, and the result is osseous union by bone formation in fibrous adhesions. Bone formation in the interlaminar and the interspinous ligaments must have been initiated from the same source.

In the vertebral bodies microbic activity has manifested itself by bone destruction. Bony invasion of the intervertebral discs, as met with in these specimens, is somewhat uncommon, but must have spread from the vertebral bodies. *Specimen II* (Th. 2–3) shows that bone formation in the intervertebral disc is a later process than invasion of the vertebral bodies; direct spread is possibly delayed by the sheets of cartilage which intervene between the vertebral bodies and the intervertebral discs.

It might reasonably be held that the dorsal vertebral arches were the earliest site of infection. In his account of acute pyogenic osteomyelitis of the spine, Steindler[3] expresses the view that the dorsal arches and the transverse processes are the commoner site of election for the pyogenic organisms, and points a contrast with the vertebral body which is preferred by the *Bacillus tuberculosis*. From time to time medical literature contains reports of cases which seem to resemble the three specimens here described. A recent report by Flemming[4] contains a radiogram which presents an appearance very like *Specimen III*, and also situated in the thoracic column. In Flemming's case, and also in the opinion of Steindler, *Staphylococcus pyogenes aureus* is considered the causative organism. General opinion seems to be that typhoid has a predilection for the intervertebral discs and for the superficial investing ligaments, though rarefaction of bone may also occur. The deformity in these specimens is not of the kind to be expected from collapse of the intervertebral discs; indeed, we know that in *Specimen II*, at least, nothing of the sort occurred. It is unlikely that these three specimens are examples of the 'typhoid spine'.

SPECIMEN V.—ANKYLOSIS OF THE THIRD, FOURTH, AND FIFTH THORACIC VERTEBRÆ

(*Figs.* 193, 194)

This specimen consists of the 3rd, 4th, and 5th thoracic vertebræ ankylosed into a formation which, from the side view in *Fig.* 193, has an appearance very suggestive of Pott's disease on account of the ventral compression of the vertebral bodies and of the dorsal separation of the spinous processes.

Fig. 193 shows contact surfaces for the heads of four ribs on the vertebral bodies, and for the tubercles of three on the transverse processes. The fused mass is considerably hollowed, and the pedicle of the middle vertebral arch, projecting forwards, fails to make contact with the vertebral body, but ends in a blunt, rough stump.

FIG. 193.

FIG. 194.

FIG. 193.—*Specimen V.* In this figure is shown a photograph taken from the right side of the ankylosed 3rd, 4th, and 5th thoracic vertebræ. The vertebral bodies have assumed a wedge formation. The bodies are compressed together in front, while the spinous processes are splayed and separated to a corresponding degree. The pedicle of the middle vertebra is separated from the fused mass of the vertebral bodies in front. On the vertebral bodies and situated rather posteriorly can be seen four articular areas which correspond to the joints of four ribs which normally articulate with three thoracic vertebræ. The mass of vertebral bodies is distinctly hollowed, but there is no surface indication of the intervertebral spaces.

FIG. 194.—*Specimen V.* In this figure is shown a photograph of the right half of the specimen after sagittal section. It can be seen that the three dorsal arches are united by a continuous sheet of bone which corresponds to the ossified interlaminar ligaments and the ventral surfaces of the laminæ. The separation of the middle dorsal arch from its body is seen in the stump of its pedicle. In the fused mass of vertebral bodies can be seen a space which is nearly central and elongated in the horizontal plane. This is the intervertebral space, which communicated with the exterior on the left side by a sinus. The bone above and below this space presents an orifice which comes to the surface in the neural canal. Each of these orifices contains the vena basis vertebræ and is a normal feature of a vertebral body. It seems, therefore, that two vertebral bodies lie on either side of the central gap, which must have contained the middle vertebra before it was broken down by disease and extruded through the sinus on the left side.

From the dorsum the outlines of the dorsal intervertebral joints are obscured by ossified capsular ligaments, but section has shown that the joint cavities are patent and the articular surfaces are normal. The interlaminar ligaments are extensively ossified.

In *Fig.* 194 is shown the right half of the fused mass after sagittal section. The dorsal arches with the ossified interlaminar ligaments, as well as the stump of the

pedicle of the middle arch, can be seen. Anteriorly lies the mass of the vertebral bodies. In the middle lies a cavity elongated fore-and-aft and closed by a bridge of bone in front and behind. On either side of the gap lies a vertebral body which, though rather dense, seems very near to normal in the regular striation and in the presence of some part of a canal which communicates with the surface posteriorly. Such a canal in a fresh specimen transmits the vena basis vertebræ and is a normal feature of a sagittal section of a vertebral body. Therefore each canal indicates that a vertebral body does indeed lie on either side of the central gap. The central gap communicates with the exterior by a hole on the left side. Unfortunately it was not possible to obtain a satisfactory photograph of the specimen from the left side because it is too severely eroded and discoloured.

The inference is that the body of the third vertebra, which lay in the middle, has been destroyed by disease, and that two practically intact bodies are left above and below bearing between them on their dorsal arches that of the missing member.

Probably the 4th thoracic vertebra was destroyed by tuberculous disease, and extruded through the sinus on the left side. A slow process of destruction by an organism of low virulence rather than an acute osteomyelitis is probable. In this case the disease has been limited to a single vertebral body in a manner which contrasts with the specimens just described.

In this specimen the disease seems to have healed, to judge from secondary effects found in the column, and this again suggests tuberculosis.

These secondary or compensatory changes include extensive ossification of ligaments, particularly those of the dorsal joints and the interlaminar ligaments of the three fused dorsal arches. Further, no doubt as a response to the requirements of a new balance to the whole column, osteo-arthritic changes are present in the dorsal joints of the three vertebræ above and below the site of ankylosis.

SPECIMEN VI.—ANKYLOSIS OF THE SECOND AND THIRD LUMBAR VERTEBRÆ

(*Figs.* 195, 196.)

In a right anterior view, *Fig.* 195 shows the two vertebral bodies united by an extensive sheet of smooth superficial bone which covers the bodies and the intervertebral space in an almost complete circuit, and therefore must correspond to the perivertebral fibrous sheath ossified. This sheet is complete except for one small gap in front and for a second on the right and behind, into which the pointer is inserted.

The dorsal intervertebral joints show some osteo-arthritis. The dorsal ligaments, except the interlaminar to a slight degree, are unossified. Sections of this specimen, shown in *Fig.* 196, display two cavities surrounded by bone and lying between the two vertebral bodies. One cavity is the intervertebral space, and extends fore-and-aft as far as the hinder and front surfaces of the vertebral bodies, where it is limited by ossified posterior and anterior ligaments. It was into this cavity that the pointer shown in *Fig.* 195 was inserted. The other cavity is situated within the body of the 2nd lumbar vertebra, and is completely closed, being separated from the intervertebral space by a wall of thin but dense bone which can be seen best on the left-hand side in *Fig.* 196.

This cavity in the vertebral body is not quite central, being nearer to the posterior than to the anterior surface. It measures 1 cm. vertically and 1·7 cm. horizontally. The intervertebral space is encroached upon by the wall of the small

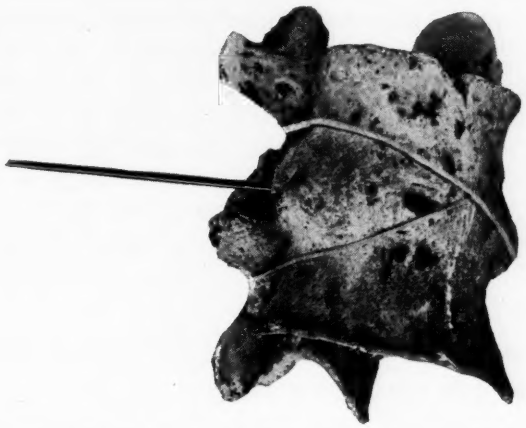


FIG. 195.—*Specimen VI.* This photograph is a right anterior view of the 2nd and 3rd lumbar vertebræ united by a superficial sheet of smooth new bone. This new bone is complete except for the gap which can be seen in front and for a second gap in a right posterior position in which the pointer is inserted. The photograph was taken after section in a sagittal plane, and shows the line of section along the front of the specimen. The two halves are retained in position by two crossing rubber bands.

cavity, which is protruded almost to meet the other vertebral body. The interior is smooth and the wall is highly compact in texture; except for some increased density in the immediate vicinity of the cavity the texture of both bones is normal.

FIG. 196.—*Specimen VI.* This photograph presents the appearances after the fused vertebral bodies had been cut in the sagittal plane. It is to be noted that two cavities lie between the two vertebral bodies. One cavity—the larger and the lower—is limited by thin bone lying in the plane of the fronts and the backs of the vertebral bodies, and corresponds to the space formerly occupied by the intervertebral disc. A smaller cavity, rather oval in section, lies in the body of the 2nd lumbar vertebra and protrudes into the intervertebral space. This smaller cavity is completely enclosed in bone, and is shut off from the intervertebral space by a plate of thin but compact bone which is best seen on the left-hand side.

During life the small cavity must have contained a tissue which exerted pressure during its growth, for it formed a compact wall and encroached upon the space occupied by the normally expansive intervertebral disc. It is easy to surmise that

in consequence the ligaments that ensheathed the two vertebral bodies were subjected to high tension, which induced the process of ossification in them.

Had the small cavity contained an abscess, collapse rather than expansion would have been expected; the wall would be rough and shaggy rather than smooth, condensed, and sharply delimited. The findings rather suggest the past presence of a tumour, non-infiltrating in character, perhaps a myeloma.

Other pathological findings in the same column include osteo-arthritis of the dorsal intervertebral joints from the 12th thoracic to the 4th lumbar and from the 3rd cervical to the 3rd thoracic. Fixation of the 2nd and 3rd lumbar vertebræ sets abnormal demands on the dorsal intervertebral joints elsewhere in the column in response to the needs of adjustment to a new balance, with the result of osteo-arthritis. These changes may be regarded as an indication of chronicity in the initial lesion.

SPECIMEN VII.—ANKYLOSIS OF THE THIRD AND FOURTH LUMBAR VERTEBRÆ

(*Figs.* 197, 198.)

It is unfortunate that this specimen was not photographed from the side before section; only the line drawing reproduced in *Fig.* 197 is available. In contrast with the last specimen the two vertebral bodies are ankylosed on each other with some degree of anterior angulation. No extensive sheet of bone such as was found in *Specimens I* and *VI* is present.

The intervertebral space is open at the sides and back and is covered in front only to a limited extent. The uniting bone is smooth and raised, but arises from no more than the margins of the vertebral bodies; elsewhere the surfaces of the bodies are normal. A large left and a smaller right anterior bridge of bone comprise the means of union.

Fig. 198 presents a photograph of the specimen after it had been cut with a fret-saw in the sagittal plane. It can be seen that the 3rd lumbar vertebra has an excavation in the postero-inferior part of its body. This excavation is evenly rounded, but its surface is rough and porous. The bone around the hollow is somewhat condensed, but no wall of compact bone has been formed.

During the partial destruction of the vertebral body and under weight-bearing there may well have been approximation of the dorsal elements of the two vertebræ. It will be remembered that in a normal column the 3rd and 4th lumbar vertebræ are dorsiflexed upon each other, as in this specimen, and this dorsiflexion may have been accentuated. Dorsiflexion is limited posteriorly by the dorsal intervertebral joints, and anteriorly by intervertebral ligaments.

It is upon these mechanisms that the brunt of the secondary pathological changes seems to have fallen. The dorsal joint between the 3rd and 4th lumbar vertebræ is markedly affected with osteo-arthritis, and the new bone in front suggests ossification in the fibres of the short intervertebral ligaments.

If the contours of the intervertebral space are followed from behind forwards, the following changes can be seen. Behind is the hollow of the site of the primary pathological process; next, for a distance, the two vertebral bodies have parallel surfaces; in front, the intervertebral space widens just where it is enclosed by the

new bone. It must be supposed that these changes in bone record changes in the intervertebral disc, and this structure, we must infer, bulged in front and gave a certain shape to bone formed in ligaments which are immediately adjacent.

These features—namely, bulging of the intervertebral disc, ossification of the short intervertebral ligaments which lie immediately outside them, and a marginal origin for new bone—are characteristic of the condition the morbid anatomy of

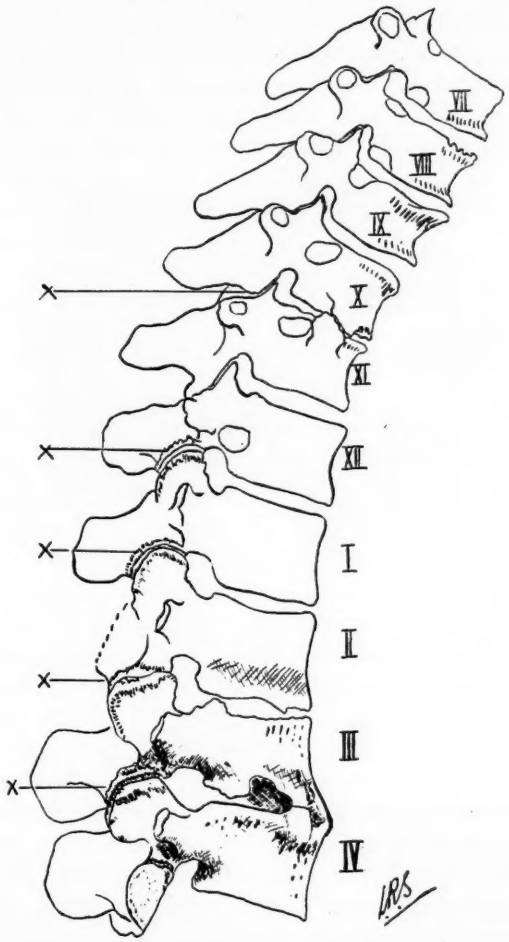


FIG. 197.—*Specimen VII.* This is a line drawing from the right side of part of the column containing the ankylosed 3rd and 4th lumbar vertebræ after reconstruction. There is some anterior angulation of the two ankylosed vertebral bodies in exaggeration of the dorsiflexion normal for the lumbar column. The union between the 3rd and 4th lumbar units is effected by osteophytes which only incompletely hide the intervertebral space. These osteophytes arise from the margins of the vertebral bodies, which for the greater part present a normal texture. Reconstruction shows that the vertebræ above the place of ankylosis are set in a uniform curve of ventriflexion, and that there is no differentiation between the thoracic and the lumbar curves. Such a contour implies general kyphosis of the spine. The dorsal intervertebral joints marked X are the seat of osteo-arthritis.

which has been described under the name 'polyspondylitis marginalis osteophytica'.[5] More commonly this condition is called 'spondylitis', perhaps with the epithet 'deformans', 'spondylitis osteo-arthritica', 'spondylosis', or 'osteo-arthritis of the spine'. In this specimen and in *Fig.* 198 it can be seen how the lines of condensation of bone radiate into the substance of each vertebral body from

the compact new bone at each vertebral margin, where are attached the short intervertebral ligaments.

The nature of the pathological process which eroded the body of the 3rd lumbar vertebra and gave rise to these changes must be a matter of conjecture. An excavation of the size could scarcely have been caused by a meningeal tumour without erosion of the other vertebra. For the same reason a tumour arising in the intervertebral disc would scarcely explain the findings. A chondroma would have caused considerable distortion of the vertebral body in which it arose, and have left traces of expansion of the bone. It is perhaps most likely that we are examining the effects of tuberculous disease of the body of the 3rd lumbar vertebra.

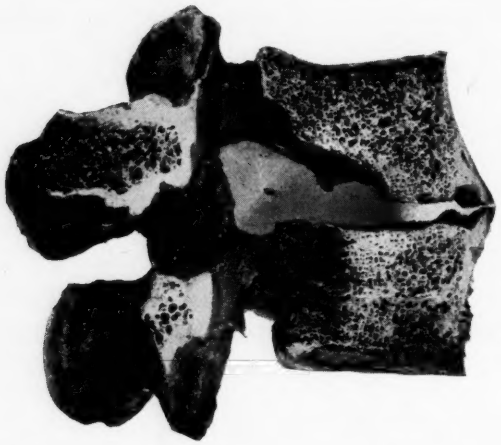


FIG. 198.—*Specimen VII.* A photograph of the left half of the ankylosed 3rd and 4th lumbar vertebræ after sagittal section. There is an excavation in the posterior part of the body of the 3rd lumbar vertebra. The excavation is uniformly curved, and though the bone around it is somewhat condensed, the surface is porous and not compressed into a firm lamina as in *Specimen VI.* It can be seen that at the seat of ankylosis in front of the vertebral bodies, where the bridge of union broke in handling, the bone is very dense. From the two points of union compact bone spreads into the two vertebral bodies. The intervertebral space in front of the hollow excavation has parallel walls which expand just where the compact bone begins. It must be inferred that the intervertebral disc bulged anteriorly, and it is probable that the new bone is formed in the short intervertebral ligaments.

The presence of changes in the dorsal intervertebral joints elsewhere in the column suggests that there was time for the column to become adjusted to new strains, and therefore that the process, whatever it was, was not rapidly fatal. Osteo-arthritis in the dorsal joints is shown in the lateral drawing in *Fig.* 197 affecting all the joints below the 10th thoracic. The interlaminar ligaments from the 9th to the 11th arches are ossified. The only part of the column available for reconstruction is shown in *Fig.* 197, from which it seems that the normal thoracico-lumbar curve has been straightened out and even reversed. There probably was a kyphotic curve to the whole vertebral column.

DISCUSSION

The specimens described illustrate the following diseases of the vertebral column to which ankylosis is a concomitant.

Specimen I.—Primary disease, probably microbic infection. Ankylosis is effected by ossification of the perivertebral fibrous sheath.

Specimens II, III, and IV.—Primary disease, probably staphylococcal infection. Ankylosis is brought about by obliteration of the joints, by ossification of the interlaminar ligaments and by bony invasion of the intervertebral discs.

Specimen V.—Tuberculous disease. Extrusion of a diseased vertebral body, and healing by ossification of ligaments.

Specimen VI.—Primary disease, a tumour of the vertebral body, probably a myeloma. Secondary ankylosis is brought about by ossification of the perivertebral fibrous sheath.

Specimen VII.—Primary disease uncertain, probably tuberculosis of the vertebral body. Ankylosis is caused by ossification of the short intervertebral ligaments.

In Ruffer's book are figured specimens which resemble *Specimens I* to *IV*, though the author does not subject them to very close analysis or to section. *Specimens I* to *IV* are all regarded as illustrating the effects of microbic infection, though these effects are much slighter in the first than in the others. Reasons for taking this view have been given already.

A feature common to these four specimens is rarefaction of bone. An obvious question arises: Is rarefaction of bone a sequel to ankylosis comparable with the atrophy of disuse? This question is not easily answered; but a limited experience, so far as it goes, does not suggest to me that rarefaction necessarily follows ankylosis. There is no rarefaction of bone in *Specimens V* and *VI*, though ankylosis is firm enough. It might be objected that there is no information available as to the relative chronicity of the pathological processes in *Specimens II, III,* and *IV* on the one hand, or in *V* and *VI* on the other. *Specimens V* and *VI* were ankylosed long enough for osteo-arthritic changes to develop in the dorsal intervertebral joints near the site of ankylosis in response, as it is surmised, to disturbances in balance of the whole column following on ankylosis.

In another place[6] I have described a specimen of developmental sacro-iliac synostosis and compared it with synostosis of infective origin. The internal structure of the first was perfectly normal; it was in the second that alteration of bone structure with patches of rarefaction were found. It does not seem from this that ankylosis *per se* brings about absorption or rarefaction of bone; rather is this effect to be attributed to diffuse inflammation or osteomyelitis.

The infective nature of *Specimens II, III,* and *IV* would be very probable from the ankylosis and obliteration of the dorsal joints, apart from rarefaction of bone and invasion of the intervertebral discs.

The term 'rhizomelic spondylitis' has been used to include those cases of ankylosis brought about by an extensive superficial sheet of new bone. This term, derived from the Greek ῥίζα spine, and μέλος membrane, is sufficiently descriptive of ossification of the perivertebral fibrous sheath. Rhizomelic spondylitis, as usually understood, corresponds to 'spondylitis ossificans ligamentosa' of Lawford Knaggs, and is distinguished by extensive ossification of the perivertebral sheath, but includes in addition ossification of the interlaminar ligaments, ankylosis of the small vertebral joints, and rarefaction of bone. An infective or 'rheumatoid' origin is the opinion almost universally held. There does not seem to be any justification for applying the term 'rhizomelic spondylitis' to *Specimens II, III,* and *IV*.

So far as external appearances go, *Specimen VI* might have been assigned to the category of rhizomelic spondylitis. Further examination shows that the

perivertebral ligaments are more probably ossified as the result of mechanical strain than as a consequence of 'rheumatoid' infection. A tumour encroached upon the intervertebral disc, which is normally expansive; hence excessive strain was set upon all of the ligaments which surround the disc and hold vertebral body to vertebral body, and that strain induced ossification in them.

That abnormal strain in ligament is sufficient cause for ossification is probably generally assumed, and the mechanism described below in the words of Macewen[7] explaining the process of ossification in tendon probably represents a general principle which covers this theorem.

> Tendons which are directly inserted into bone, without the intermediary of the periosteum, are, under exceptional circumstances, liable to osseous infiltration . . . mechanical irritation causes a proliferation of osteoblasts which penetrate the . . . fibres of the tendon and set up ossification in their midst. Some of the fibres . . . may retract into the tendon, carrying osteoblasts from their point of insertion. Rider's bone results in this way.

In another place[8] I have tentatively explained the very common finding of ossified interlaminar ligaments as the result of strain or trauma following on ventriflexion of the vertebral column, and commonest in the thoracic region because the thoracic units are normally ventriflexed on each other and supported in that position by the interlaminar ligaments. This might be held to illustrate the principle set out above. Vertebræ with the interlaminar ligaments ossified to a greater or lesser extent are very common in Egyptian columns, and this makes the finding of Ruffer on this point the more remarkable. Writing on 'spondylitis deformans' in Egyptian skeletons, he states: "On the other hand the ligamenta subflava (interlaminar ligaments) composed of yellow elastic tissue always remained free from ossification".[9] I strongly dissent from this opinion.

In *Specimen III* ankylosis is brought about by direct bony union of two vertebral bodies after extrusion of a diseased intermediate member. The interlaminar ligaments are completely ossified, it may be suggested, because they were subjected to strain in resisting separation of the dorsal arches in the position of extreme ventriflexion which followed collapse of the intermediate vertebral body. In the stages prior to healing, these ligaments must have been the chief local support of the three acutely flexed vertebræ, and probably represent the earliest site of new or reparative ossification.

In one of his papers Ruffer[10] interprets two tomb carvings of the XI–XIIth and of the XVIIIth Dynasties as examples of Pott's disease of the spine, and states that he knows of no others in Egypt. His collection of bones apparently did not contain an example like *Specimen III*.

In several places reference has been made to concomitant osteo-arthritis in the dorsal intervertebral joints, and this finding has been adduced as evidence of chronicity. Timbrell Fisher defines osteo-arthritis as "the series of physiological or pathological changes that occur in a joint when it is subjected to oft-repeated injury, either mechanical or toxic, but of a moderate degree of intensity".[11] Pointing out that osteo-arthritis may be an expression of abnormal stresses laid upon a joint, Fisher gives among the causes of "traumatic or localized" osteo-arthritis this example: "a localized increase of articular stress of an occupational nature or caused by . . . ankylosis of an adjacent joint".

Ankylosis of two or more vertebræ may be supposed to cause an unusual stress to fall upon the dorsal intervertebral joints above and below the site of union,

and therefore to render those joints prone to the development of osteo-arthritis. This inference follows from Fisher's theorem, and also the further inference that in those specimens in which osteo-arthritis is an apparent concomitant of ankylosis the main pathological lesion must be of longer duration than is necessary to bring about the development of osteo-arthritis.

In his account of pathological lesions of the vertebral column Ruffer describes and figures specimens of ankylosis brought about, as it seems, by ossification of the perivertebral fibrous sheath, and a much larger number exhibiting osteophytes of the type that causes the familiar 'lipping' of the vertebral bodies. This type of osteophyte Ruffer considers to be that most characteristic of 'spondylitis'. Lipping, or polyspondylitis marginalis osteophytica, I believe to be the result of bone formation in the short intervertebral ligaments, brought about by strain when vertebra slips or rotates upon vertebra as a consequence of change in the intervertebral disc. Though this condition is the commonest of pathological changes in Egyptian vertebral columns, I have not obtained a specimen in which ankylosis had resulted except *Specimen VII*, and in this the initial lesion is highly unusual.

Ruffer makes an interesting deduction as to the development of the social sense in the communities of ancient Egypt. The individuals with the pathological lesions described in this paper must have been crippled and for a long time unable to exist by their own efforts, or to bear a share in the communal life of a primitive people. It is inferred that the care of the sick was a duty even in Predynastic times in ancient Egypt. *Specimen V*, healed tuberculosis of the spine, points in this direction, and even more strongly *Specimen VII* (if it is tuberculous), because diagnosis must have been much more difficult, and healing has taken place at a much earlier stage.

I have to acknowledge with thanks the opportunities given me by Prof. J. T. Wilson and by Dr. W. L. H. Duckworth to examine the series of vertebral columns stored in the Anatomy Department at Cambridge. Sir Walter Langdon-Brown, when Regius Professor of Physic at Cambridge, and the M.D. Committee, gave me permission to publish these observations, which formed part of a Thesis presented for the degree of M.D. in 1933.

REFERENCES.

[1] RUFFER, SIR MARC ARMAND, *Studies in the Palæopathology of Egypt*, 1921, 248.
[2] KNAGGS, R. LAWFORD, *The Inflammatory and Toxic Diseases of Bone*, 1926, 172 et seq.
[3] STEINDLER, *Diseases and Deformities of the Spine and Thorax*, 1929, 463.
[4] FLEMMING, CECIL, *Proc. Roy. Soc. Med.*, 1935, xxvii, 897 et seq.
[5] SHORE, L. R., "Polyspondylitis Marginalis Osteophytica", *Brit. Jour. Surg.*, 1935, xxii, 850.
[6] SHORE, L. R., "A Specimen of Developmental Sacro-iliac Synostosis", *Jour. Anat.*, 1930, lxiv, 503.
[7] MACEWEN, WILLIAM, *The Growth of Bone*, 1912, 135.
[8] SHORE, L. R., "A Report on the Nature of Certain Bony Spurs Arising from the Dorsal Arches of the Thoracic Vertebræ", *Jour. Anat.*, 1931, lxv, 379.
[9] RUFFER, *Loc. cit.*, 242.
[10] RUFFER, "On Dwarfs and other Deformed Persons in Ancient Egypt", *Loc. cit.*, 42.
[11] FISHER, TIMBRELL, *Chronic (Non-tuberculous) Arthritis*, 1929, 89 et seq.

MULTIPLE ARTHRITIS IN PRESUMABLY TUBERCULOUS SUBJECTS: DIFFICULTIES IN DIAGNOSIS AND TREATMENT

By DOUGLAS H. COLLINS
RHEUMATISM RESEARCH FELLOW OF THE UNIVERSITY OF LEEDS
AND CHARLES CAMERON
MEDICAL SUPERINTENDENT, EAST FORTUNE SANATORIUM, EAST LOTHIAN

INTRODUCTION

Diagnostic Inaccuracies.—Tuberculosis of a single large joint, e.g., hip or knee, in young persons before the age of puberty, can usually be diagnosed correctly after clinical and radiological examination. After puberty other types of 'non-specific' infective arthritis may make their appearance, and these must be considered in arriving at a diagnosis. Smith and Watters[1] found that the diagnosis was wrong in 22 per cent of 208 patients admitted for tuberculosis of the hip to the County Branch of the New York Orthopædic Hospital, and Smith[2] reports the findings in 24 cases of monarticular arthritis simulating tuberculosis which were submitted to exploratory operation. Histological examination and animal inoculation excluded tuberculosis in these cases. Smith remarks that the classical signs of tuberculosis of a joint are just as common in other joint diseases. Milgram[3] points out that diagnostic inaccuracies may operate also in the other direction, and that 38·7 per cent of 142 proved cases of tuberculosis of bone, joint, and bursa were not so diagnosed. Ghormley and Brav[4] record errors of diagnosis in 24·4 per cent of cases of supposed tuberculous arthritis and 13·7 per cent of supposed non-tuberculous arthritis affecting the knee.

Diagnostic Methods.—

Guinea-pig Inoculation of Aspirated Material, and Histological Examination of Tissue obtained by Biopsy.—The necessity of these methods of diagnosis is repeatedly stressed in American literature. The consistently obvious demonstration of tubercle formation in Allison and Ghormley's[5] cases convince one of the value of the histological method, and Ghormley and Brav[4] found the histological examination to be correct in all but 3·2 per cent of 158 cases, although in 22 cases additional sections were necessary in order to demonstrate the lesion. Out of 24 tuberculous cases tested by animal inoculation, 3 failed to demonstrate the nature of the disease. Biopsy is not so commonly practised in Great Britain, and Girdlestone[6] writes that diagnostic arthrotomies are not always indicated in suspected tuberculosis of the knee, and false negatives are said to be common: a view which is also held by Forrester-Brown[7] in regard to the early diagnosis of hip-joint tuberculosis.

X-ray Diagnosis.—The question of the radiological diagnosis of early joint tuberculosis has been widely discussed. Although Fraser,[8] Rogers,[9] and other authors believe that the primary tuberculous focus is more often in the synovial tissues of a joint than in the bone, Allison and Ghormley[5] have found coincident

invasion of subchondral bone in all their cases. These authors make it clear, however, that it is possible to have active tuberculosis in bone and joint without any demonstrable change in the X-ray picture.

Smith[10] says that decrease in the width of the joint space is a fairly early sign, and that evidence of bone destruction was present in very few of the early cases. Phemister[11, 12] has shown that in tuberculous arthritis, in contradistinction to other forms of infective arthritis, the articular cartilage is often preserved at the points of contact of articular surfaces, and in radiographs the cartilage space often maintains its usual width.[13] Certainly, if the joint space is maintained, in spite of associated bone destruction, there is a strong presumption of tuberculosis (Pomeranz),[14] but loss of joint space is not a point against tuberculosis. Radiology does not help in the differential diagnosis until the comparatively late stages when there is evidence of bone destruction.

Henderson and Fortin[15] think there is no typical X-ray picture of tuberculosis of the knee. They rely on the history and objective data to reach a diagnosis, and in differentiating tuberculosis from 'chronic infectious arthritis' they note that the latter is commoner in more elderly patients, and that in non-specific arthritis of the knee-joint either other joints become involved within a year, or the knee recovers after suitable treatment such as eradication of infective foci. In our experience, however, neither of these results may ensue, and the diagnosis may still remain in doubt. In this connection it may be well to recall the dictum of Smith[10]: "The idea that it is safer to treat the case conservatively at first and to await developments is a fallacious one, because, once immobilization is started, the condition is obscured indefinitely." Smith confines his cases to bed, but without immobilization, for such a time as may allow an evanescent arthritis to clear. If this does not occur, he performs an exploratory operation.

Tuberculin Reaction.—Without indulging in a full discussion of this well-worn subject, we may say with Atsatt[15] that a positive reaction, quantitatively controlled, can only be presumptive of osseo-articular tuberculosis until all other possible active foci have been excluded, whereas a negative reaction, in the absence of certain modifying factors (overwhelming tuberculous infection, advanced sepsis, anæmia, or other grave disease), can eliminate the diagnosis of tuberculosis with some certainty. Occasionally an acute focal reaction in a joint, as in the case described by Bezançon and his colleagues,[17] may indicate the tuberculous nature of a local arthritis. Reliable focal reactions are, however, rarely obtained when using the intracutaneous or Mantoux technique. We should like to call attention to the Tuberculin P.P.D. (Purified Protein Derivative) manufactured by Parke, Davis & Co., with the small first dose of which all highly sensitive cases can be detected without danger of a very severe reaction (Long, Seibert, and Aronson[18]). This is an accurately standardized preparation, with which quantitative reactions of some value can be obtained.

Considerable difficulties, therefore, may exist in the early differential diagnosis of the monarticular arthritides in adolescence and in the first decade of adult life. This matter of diagnosis is of far more than theoretical importance. Early immobilization might prevent destruction of bone in a tuberculous joint, but in a non-specific arthritis would not only subject the patient to an unnecessarily long and expensive in-patient treatment, but might result in an otherwise preventable

ankylosis. A joint with only 30° of useful movement is a far more valuable possession than an ankylosed joint, no matter how perfect the orthopædic position may be.

MULTIPLE ARTHRITIS AND TUBERCULOSIS

It may not seem so likely that confusion should occur in diagnosis in the case of a multiple arthritis, but that this does happen has been made clear in our experience and in the case records which we present. Many factors account for this confusion :—

1. The insidious monarticular onset of some cases of multiple non-specific arthritis.

2. The coexistence in the patient of some visceral tuberculous lesion, which may or may not influence the course of a non-tuberculous polyarthritis.

3. The possible occurrence of a single tuberculous joint superimposed upon a non-tuberculous multiple arthritis.

4. The occasional incidence of true tuberculous arthritis in two or more joints.

5. The comparative infrequency of non-specific arthritis of the hip in patients under middle age, and the tendency to suppose such a condition to be tuberculous.

6. Modification of the course of non-specific arthritis due to early immobilization.

7. The possibility that there exists an atypical tuberculous form of polyarthritis —tuberculous rheumatism.

We need not again emphasize the importance, both for treatment and prognosis, of a proper knowledge of these questions in diagnosis. Each will be discussed and illustrated, where possible, by cases from our own experience.

1. The Insidious Monarticular Onset of some cases of Multiple Non-specific Arthritis

Case 1.—Female, employed as machinist. No family history of tuberculosis. In 1929 she developed pain and swelling in the right knee. Three months after onset this was diagnosed as tuberculous arthritis of the knee. She was sent to a sanatorium and treated in extension and later in plaster for 3½ years. At the age of 23, while still in the sanatorium, symptoms arose in the left elbow and in the left wrist. These were still thought to be tuberculous, and were treated by fixation in plaster. The wrist became ankylosed, with an awkward radial deflection of the hand and wrist-drop. The symptoms in these three joints gradually subsided and she returned home in 1933.

A year later, however, an arthritis developed in the right elbow, and on admission to the Harrogate Royal Bath Hospital at the end of 1935, this was the most actively diseased joint. Her condition after admission to this hospital was as follows :—*Rt. elbow* : Fluid swelling of joint ; the muscles supporting the joint were extremely atrophied and weak ; almost full passive movement could be obtained. *Lt. elbow* : Flexion and extension limited to about 30° of movement ; no pain. *Lt. wrist* : Rigid, with radial deviation of the hand. *Rt. knee* : Full extension not obtainable, but about 70° of movement possible. X-ray examination showed slight erosions and loss of cartilage space in all joints, bony ankylosis of the left wrist, and secondary osteophyte formation and periosteal reaction in right knee and left elbow. Aspiration of fluid from the right elbow was performed on two occasions. The total nucleated cells numbered 34,500 and 40,000 per cm., with 90 per cent of polymorphs (commensurate with that found in the rheumatoid type of chronic arthritis[19]). Cultures were sterile, and guinea-pig inoculation negative. The anterior end of the 4th right rib was splayed out as if by medullary expansion. There was a slightly tender swelling over this site at the time of her admission, but the swelling subsided. We are unfamiliar

with the radiographical appearances: they were not suggestive of tuberculosis. Blood Wassermann reaction was negative on two tests. Tuberculin reaction with P.P.D. Tuberculin was 3 + with the first test dose; no active focus of tuberculous infection, however, was found.

Physical therapy and general spa treatment greatly improved this patient, restoring almost full active movement to the left elbow and a bigger range of movement in the right knee. She has since returned to her work.

This is an unusual form of multiple arthritis to encounter in a female. The small joints of the hands and feet were never involved and the lesions were asymmetrical. Against the original diagnosis of tuberculosis were the absence of definite radiological evidence of tuberculosis even after six years of the disease, the particularly chronic course of the disease, the examination of the joint fluid from the elbows, and the improvement of function resulting from methods of physical therapy. The only confusing point was the strongly positive tuberculin reaction. The possibility of syphilis was considered, but discarded after failing to find any clinical confirmation, and after two negative Wassermann serum tests. No source of infection was discovered. Periods of one or two years elapsed between the successive joint involvements. There is no doubt that this slow progress of the disease accounted for the confusion in diagnosis. It is impossible to say to what extent the immobilization and general régime of the sanatorium influenced the course of the disease, and delayed the spread to other joints. Apart from the possibility that the condition might have become more generalized had she not been so dealt with, we think that the treatment adopted was detrimental to functional activity of her joints, and that the period of her economic incapacity was unduly prolonged.

2. The Existence of some Visceral Tuberculous Lesion which may or may not Influence the Course of a Non-tuberculous Polyarthritis

Case 2.—Mrs. A. E., aged 59 years, was seen by one of us (C. C.) at the request of her doctor, and was admitted to East Fortune Sanatorium. We had known for many years that she suffered from rheumatoid arthritis, but the reason for the requested visit was a sudden hæmoptysis.

She had evidence of old tuberculous disease in the form of neck glandular scars, and chains of small very hard glands were easily felt in both posterior triangles of the neck. When questioned, she gave a history of a glandular abscess at the age of 16 years, and of the removal of her right index finger for disease which appeared at the age of 24 years after a trivial accident. This was almost certainly a tuberculous condition. The X-ray examination showed the shadows of densely calcified glands in the roots of both lungs, small calcified shadows below both clavicles, and a light infiltration, which appeared to be of recent development, of the upper half of the left lung. She had advanced rheumatoid arthritis, with the typical deformities of the advanced disease. Every joint in her limbs appeared to be affected, and the deformities of hands and feet were gross. The disease was most active in the knee-joints, each of which had a flexion deformity and subluxation of the tibia with genu valgum. The X-ray appearances were typical of advanced rheumatoid arthritis. She was a thin woman of poor physique, and there was gross muscle atrophy associated with the joint conditions. She had a good deal of intestinal discomfort, and her stools were bulky and semi-formed, intensely fœtid, and contained undigested food. Fractional gastric analysis showed a complete achylia. She improved very greatly with treatment in the Sanatorium. This treatment included two courses of gold injections, a long course of careful orthopædic and physical treatment, and finally a double osteotomy to correct the gross bilateral genu valgum.

Case 3.—Mrs. A. A., aged 38, was admitted to East Fortune Sanatorium on Oct. 12, 1929. She gave a history of having suffered from pleurisy 18 years previously, and of having had intermittent fever and cough since a confinement 12 years before. Four years after the

development of the cough she developed rheumatoid arthritis, and when she came to the Sanatorium was in a very poor condition. Her sputum contained tubercle bacilli, and the X-ray film showed dense fibroid tuberculous disease of the left upper lobe containing several cavities, with lighter fibrotic disease of the lung below and of the right apex. She had frequency of micturition and pain, with intermittent pyuria, which we finally traced to the presence of stones in the bladder and right kidney. On March 28, 1932, Mr. Mercer, surgeon to the Sanatorium, removed a stone weighing 19 gr. from the pelvis of the right kidney, and on May 5 he removed a mulberry calculus of the size of a horse-chestnut from the bladder. The urinary symptoms did not recur. She had extensive rheumatoid changes in elbows, wrists, knees, feet, and in the small joints of the hands, with characteristic X-ray appearances. Some years previously her tonsils had been removed and an infected left antrum had been drained. If one were to look for an initial focus, the urinary and other sepsis would have to be considered in addition to the tuberculous disease of her lungs.

The lung disease improved greatly, contraction of the fibrotic left upper lobe being helped by a phrenic evulsion which was performed on June 25, 1931. The joint condition had begun to improve before the kidney and bladder operations, and it seemed to us to improve coincidently with the improvement of her lung disease. At the time of her discharge the disease in most of the joints was quiescent, and though many of them were deformed they had a useful range of painless movement. The left knee-joint remained swollen and rather painful, but was improving.

It is difficult to assess the part which tuberculosis may have played in the rheumatoid arthritis of these two patients. In both cases the tuberculous infection preceded the appearance of the rheumatoid condition, and it would be an easy conclusion to state that the one was secondary to the other. Such a view cannot be readily accepted, for in both patients there were many other points to consider. In *Case* 3 there was a history of sepsis antecedent to the rheumatoid arthritis, while in *Case* 2 there were intestinal disturbances (achylia and fœtid stools) which might with equal reason be held as relative to the rheumatoid disease. We are inclined to regard the tuberculous disease and the rheumatoid arthritis as independent affections in these two patients.

The two diseases occur but rarely in the one patient. These two patients (*Cases* 2 and 3) are the only cases of true rheumatoid polyarthritis which have been admitted to East Fortune Sanatorium during the past 13 years. In that time 1562 patients over the age of 15 years with pulmonary tuberculosis, and 617 patients over the age of 15 years with non-pulmonary tuberculosis (207 of whom suffered from bone or joint disease) have been treated at the Sanatorium. This incidence is slightly lower than that found by Lawrason Brown at Saranac Lake (quoted by Pemberton[20]), whose figures were 11 cases of positive rheumatoid involvement among 4499 cases of pulmonary tuberculosis. Pemberton states that active tuberculosis was very infrequent among patients with non-specific arthritis, and Brav and Hench[21] discovered only 8 out of 250 patients with rheumatoid arthritis who had definite tuberculosis elsewhere than in the joints—a lower incidence of tuberculosis than in a corresponding number of non-arthritic patients. It is clear, then, that tuberculosis is sufficiently rare in rheumatoid arthritis, and polyarthritis is sufficiently rare in tuberculosis, to enable us to refute the suggestion that tuberculosis is a frequent or an important factor in the etiology of the other disease. The occasional coincidence of the two diseases in the one patient is illustrated by our two cases and by a few others in the literature, but we intend to postpone the more detailed discussion of these and of what is meant by ' tuberculous rheumatism ' until we have described our other cases and the different problems which they present.

3. The Occasional Occurrence of a Single Tuberculous Joint Superimposed upon a Non-tuberculous Polyarthritis

Pathological observations by Brav and Hench[21] disclosed evidence of tuberculosis of a single joint in 8 out of 75 cases diagnosed before operation as chronic infective polyarthritis. In each of these 8 cases the diagnosis of tuberculous arthritis of the single joint was suspected before operation, but the associated generalized arthritis introduced a confusing factor. While Brav and Hench cannot entirely disregard the possibility of an atypical multiple tuberculous arthritis, they suggest that tuberculous infection may have developed in one joint, the resistance of which was lowered by previous attacks of non-tuberculous polyarthritis. This seems especially probable in five of their patients in whom the generalized arthritis was primary, localization occurring later in one of the joints. Our *Case* 4 is an illustration of this type. A severe arthritis of one knee, clinically and radiographically suggestive of tuberculosis, developed some years after the onset of a generalized arthritis in a young girl. A marked focal reaction in this knee and a general reaction followed the injection of tuberculin. There was also a tuberculous focus in the lung.

Case 4.—J. P., female, aged 16 years. At the age of 8 years, this patient had an attack of rheumatism with stiffness and pain in both wrist-joints. The attack lasted about seven months. At the age of 11, and again at 14 years, she had further attacks of rheumatism, the disease spreading to, and remaining in, the elbows, shoulders, knees, feet, and hands. There was no cardiac disease.

On admission to the Harrogate Royal Bath Hospital, she had all the appearances of chronic non-tuberculous polyarthritis. The wrists had a few degrees of movement, although radiographically they showed bone atrophy with scattered centres of rarefaction and slight erosions. The elbows were swollen and not very painful, and showed no significant changes on X-ray examination. The shoulders and ankles were stiff and limited in movement. There was spindle deformity of many of the finger-joints. The right knee appeared to be unaffected. The left knee, however, was swollen, hot, and extremely painful to touch or movement. Starting pains at night were experienced in this joint. There was muscle wasting above the joint. The X-ray film showed slight bone rarefaction and erosion in the region of the tibial spines, the cartilage space being well maintained. The affection of this (left) knee had developed within the last few months, and it was clear from the history she gave that the joint had been becoming progressively worse, while the other joints had been improving. An intradermal tuberculin test was made with 0·1 c.c. of 1–1000 Old Tuberculin, and a +++ local reaction developed. At 48 hours after the test the temperature had risen to 99·6°, there was general malaise, and a very marked exacerbation of symptoms in the left knee. No focal reaction occurred in any other joint. There was clinical and radiological evidence of a not very active tuberculous focus in the right infra-clavicular area of the lung.

The left knee was diagnosed as true tuberculous arthritis, and was immobilized in plaster. The patient was later transferred to an orthopædic hospital.

4. The Occasional Incidence of True Tuberculous Arthritis in Two or More Joints

In a series of 168 cases of tuberculous arthritis of the knee, Ghormley and Brav[4] found two joints affected in 13·1 per cent, and more than two joints affected in 5·4 per cent, of their cases. Brav and Hench,[21] however, consider that when more than three joints are the seat of arthritis it is not very likely that the arthritis is due to tuberculosis. Allison and Ghormley[5] describe one proved case of multiple tuberculous arthritis affecting elbows, wrists, knees, and tarsus. In this case there

was much bone destruction and periosteal reaction, also general glandular enlargement, and discharging sinuses leading from the right tarsus. This case is so clearly one of multiple tuberculous foci, that it in no way resembles the much debated form of ' tuberculous rheumatism '. We believe that the infrequency of multiple tuberculous arthritis has been exaggerated in common medical opinion. In East Fortune Sanatorium, during the past thirteen years, there have been at least 7 patients with multiple foci among 207 cases of osseo-articular tuberculosis. From these we may quote *Cases* 5 and 6 as examples of the condition. This type of disease must be considered when reaching a diagnosis in an atypical multiple arthritis, but evidence of the true tuberculous nature of the condition is nearly always readily at hand.

Case 5.—J. T., female, aged 24 years, was a patient in East Fortune Sanatorium from 1930 to 1934. At the age of 18 she had suffered from pleurisy, which was followed by a rib abscess. At the age of 24, following an injury, her right knee became swollen, and it was for this condition that she was sent to the Sanatorium.

There was a typical tuberculous arthritis of the right knee, and the joint was finally excised and fixed by arthrodesis. Previously unsuspected tuberculous disease of the dorsal spine was found on admission. This involved the 5th, 6th, and 7th dorsal vertebræ. These lesions healed well, but she died two years later of tuberculous meningitis.

Case 6.—S. McG., female, aged 30 years, was admitted to East Fortune Sanatorium on June 18, 1932, and died on July 12. She had tuberculosis of her lungs with tubercle bacilli in her sputum. X-ray examination showed a large calcified abscess overlying the upper part of the sacrum and obscuring the lower lumbar spine. She had had spinal symptoms some years previously, and there is no doubt that this was an old psoas abscess. There was advanced tuberculous arthritis of the left knee-joint, which was full of tuberculous pus. The right hip-joint was stiff and painful, and the X-ray film showed extensive destruction of the joint with ankylosis.

5. The Comparative Infrequency of Non-specific Arthritis of the Hip in Patients under Middle Age, and the Tendency to Suppose the Condition in such Persons to be Tuberculous

Symptoms in five of the patients whose notes are included in this paper commenced in the hip-joint. These patients were diagnosed, in the first place, as suffering from tuberculous hip disease. The subsequent course of the disease and later investigations rendered this diagnosis untenable. Two of them we believe to have been cases of ankylosing spondylitis, the typical course of which was modified by their early treatment, and these will be described in the next section. Three others (*Cases* 7, 8, and 9) suffered from an atypical type of arthritis of the hip-joints. None resembled the usual form of rheumatoid arthritis, for the smaller peripheral joints were not implicated.

In our own experience objective or subjective signs of hip-joint disease are exceedingly uncommon in rheumatoid arthritis. Pemberton[20] also says that in the hip external visible evidence of the true pathological process may be lacking throughout, and Forestier[22] states that he found only 10 cases of affection of the hip in more than 250 cases of progressive polyarthritis, and only 3 of these were bilateral. In only one instance in Forestier's cases did symptoms in the hip initiate the disease. Forrester-Brown[23] discusses the differential diagnosis of abnormal hip conditions in children, and mentions " arthritis of true rheumatic origin, less acute than

rheumatic fever, and another of quite unknown origin" as common causes of hip symptoms in children. She considers that the majority of so-called tuberculous hips which healed in the past with little or no immobilization were of this nature, and Telford[24] thinks that recovery with full movement of a hip-joint, diagnosed as tuberculous, must cast considerable doubt on this diagnosis.

We wish to emphasize, however, that though a painless joint will be the eventual result in all cases of non-tuberculous arthritis, immobilization, adopted on an incorrect diagnosis, may result in serious and unnecessary limitation of movement and may also actually delay recovery.

Case 7.—J. W., female, was admitted to East Fortune Sanatorium on Nov. 12, 1930, with a diagnosis of tuberculous disease of the left hip-joint. She was then 13½ years of age, and had been quite well until a month previously when pain appeared in this joint. The onset of the pain was gradual. She was admitted to a general hospital where it was observed that a dull pain was constantly present and referred to the outer aspect of the thigh, the front of the knee, and the calf. A few hard glands in the right posterior triangle of the neck had been detected, and despite somewhat indefinite X-ray findings she was diagnosed as having tuberculosis of the left hip-joint.

FIG. 199.—*Case* 7, Aug. 19, 1932. Non-specific infective type of arthritis of both hip-joints. The left hip has been affected for 18 months, the right for about 4 months. There is loss of cartilage space of both joints and general loss of bone density, more marked on the left side. In spite of the duration of the affection there is little or no erosion of bone, and recovery with greatly increased movement was eventually obtained.

On admission to the Sanatorium the patient was in a poor general condition, with a dry skin and appearances which suggested a chronic tuberculous infection. She gave a strongly + reaction to the Mantoux test (1–1000), and the left leg was fixed in a position of slight abduction and external rotation. There was tenderness to pressure on the head of the femur, all hip movements were in abeyance, and many small hard glands were present in the left inguinal region. An X-ray examination of the left hip showed merely loss of bone density and slight narrowing of the joint space, and, though not definitely diagnostic of tuberculous disease, that diagnosis was accepted.

A few days after admission extension was applied to the limb. By February, 1931, movement had returned to this joint, but the left knee was now enlarged and its range of movement was diminished. Her general condition was much better. By November, 1931, movement of the left hip had again become restricted, the left knee was very stiff and painful, and creaking and stiffness had appeared in the right knee. During this time the diagnosis of tuberculosis had been questioned on several occasions, but the diagnosis was not altered.

After symptoms had appeared in the right hip a radiograph showed narrowing of the joint space of both hips, with loss of bone density, more marked on the left than on the

right side. The contour of the articular surfaces remained regular in spite of the disease having been present in one of the joints for 18 months (*Fig.* 199). This was in April, 1932, and extension was applied to both legs. Movement became gradually less until at the beginning of 1934 the left hip seemed to be ankylosed, both knees were almost completely stiff, and movements of the right hip were reduced to a few degrees of flexion. Under a general anæsthetic, however, both hips moved freely and movement was present in both knees. The diagnosis of tuberculosis was then definitely discarded. Other lines of treatment were adopted to deal with the multiple arthritis. These included a course of T.A.B. injections, massage, and passive movement of the joints, and some improvement was effected.

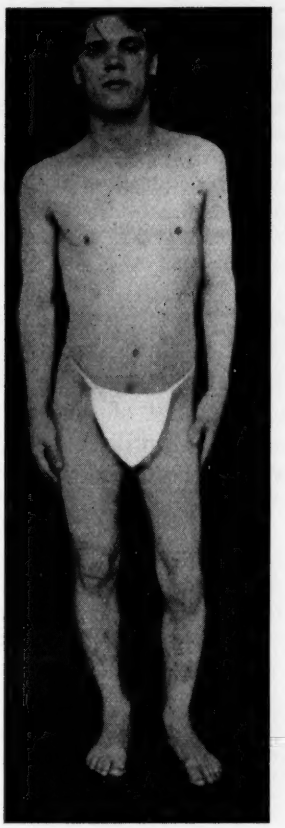
On Aug. 27, 1934, the patient was transferred to the Harrogate Royal Bath Hospital. She had still extreme limitation of movement of both hips, and wasting of the thigh and gluteal muscles. Her knees were stiff and crepitus was present in them, but there were several degrees of active movement. Pain was not conspicuous, but fatigue resulted from very little exercise. She walked with great difficulty with two sticks. The hips were held rigidly, and progress of a shuffling type was possible only by swinging the whole body. Treatment consisted of sulphur immersion baths and H.F. diathermy to both hips, followed by gentle massage and movements. She recovered movement and strength in a remarkable manner. After five weeks she could walk a distance of more than a mile, only using one stick when going uphill. Movement of the hips continued to increase and she was discharged on Oct. 13, 1934. Her condition has continued to improve, and she now leads a life of normal activity.

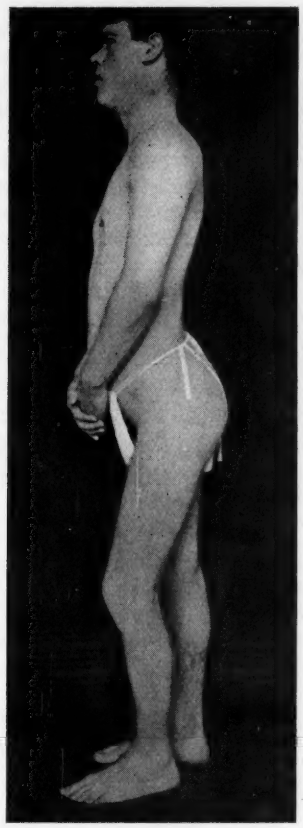
The case of this patient illustrates very clearly the type of arthritis of the hip in young persons in which diagnosis is mistaken and treatment misapplied. It is possible that the condition is far commoner than is generally recognized, and that many young patients have suffered unnecessary years of immobilization. Our patient was a tuberculous subject, but there is no reason to think that the arthritis was tuberculous, and we see now that the prolonged rest and extension was incorrect. Immobilization in her case only resulted in further limitation of movement of the joints, but function was fortunately regained after a course of spa treatment. All the early appearances of this patient were suggestive of tuberculous disease. The diagnosis was finally corrected by the absence of radiological evidence of bone destruction even after some years, the development of multiple joint affections, and the freedom of joint movement under anæsthesia.

Case 8.—A. B., male, aged 14 years, was admitted to East Fortune Sanatorium on May 7, 1930. In March of that year he had developed slight pain in the left hip. He was seen on several occasions as a surgical out-patient at a general hospital, and was diagnosed as early tuberculous disease of the joint.

He came into the Sanatorium in poor general condition. His tonsils were enlarged and inflamed and he had many carious tooth stumps. Chains of small hard glands were present in the posterior triangles of both sides of the neck, and he gave a strongly positive reaction to the von Pirquet test. The left hip-joint was in a normal position, but movement was restricted in all directions. X-ray examination of this joint was inconclusive; there was loss of bone density around the joint and a slight irregularity of the lower third of the articular surface of the femoral head. The limb was fixed in plaster for a period of eight months. At the end of that time he had painless movement of the hip-joint in all directions to about 50 per cent of the normal range. The X-ray film then showed narrowing of the joint space, but no further bone destruction. The diagnosis of tuberculosis was doubted and the patient was now left in bed without plaster and encouraged to move the joint. Stiffening, however, took place, and he left the sanatorium with only a few degrees of movement of the hip. During his stay he had several crops of subcutaneous abscesses, possibly related to his dental infection.

The patient was seen at intervals under the After-Care Scheme, and on Nov. 5, 1935, it was found that the left hip had become fixed in a position of flexion and slight adduction. The deformity resembled that of tuberculous hip disease (*Figs.* 200, 201). He was re-admitted





FIGS. 200, 201.—*Case* 8, Nov., 1935. The figures show a flexion-adduction deformity with shortening of the limb, what one would expect typically in a chronic tuberculous arthritis.

FIG. 202.—*Case* 8, Nov. 14, 1935. Non-tuberculous arthritis of the left hip. The pelvis is tilted on account of the deformity shown in *Fig.* 201. The disease has been present for 5½ years. There is hardly any destruction of the articular surfaces. The joint space has re-formed and some dense new bone formation is to be seen about the lower lip of the acetabulum and the lower articular margin of the femur. The joint is quite painless, and mobile under a general anæsthetic.

to the Sanatorium for corrective treatment, but interference with the joint has been discouraged because we feel sure that the condition is not tuberculous and that correction should eventually be obtained by conservative measures. X-ray examination now shows no further destruction of bone, an apparent re-formation of the cartilage space, and some new dense bone formation about the lower lip of the acetabulum and the lower third of the articular surface of the femur (*Fig.* 202). Under a general anæsthetic, the left hip, though flexed to about 45°, was quite definitely mobile, about 15° of flexion, 10° of abduction and adduction, and a little rotation being easily obtained. The Wassermann reaction is negative, but he still reacts to tuberculin, a 1+ reaction being given to the first test dose of Tuberculin P.P.D. His general condition is very good. There is no pain, and despite the deformity he goes about actively and comfortably.

This patient has some features in common with the preceding *Case* 7, although one joint only was affected. The gradual resolution of the arthritis without bone destruction resulted, in each case, in a stiff though painless joint. Evidence of a quiescent glandular tuberculosis in each case and the onset of symptoms referable to the hip-joint led to the faulty diagnosis of tuberculous hip disease. It is possible that the septic state which produced subcutaneous abscesses was also responsible for the arthritis.

Case 9.—M. P., female, aged 22 years, was a patient in East Fortune Sanatorium from Sept. 4, 1926, to Sept. 21, 1930. She was a tuberculous subject, and had had tuberculous glands removed from the right side of the neck some years previously. Many palpable glands were present in other areas of the neck and in the abdomen. The Mantoux test was strongly positive.

FIG. 203.—*Case* 9, Aug. 29, 1934. Bilateral protrusio acetabuli. The patient had suffered from an arthritis affecting both hip-joints, but the protrusio acetabuli was present to the same degree at the first radiographic examination at the onset of symptoms 8 years previously. There is slight moulding of the head of the left femur, which also shows some cyst-like centres of rarefaction. These features have appeared since the early days of the illness. This patient was tuberculous, but there is nothing to prove that the arthritis was also tuberculous.

On admission the left hip-joint was fixed in a vicious position and showed all the clinical signs of a tuberculous arthritis. The movement of the right hip-joint later became restricted, and there was creaking in both knee-joints. The left hip seemed to be ankylosed. At the first X-ray examination, on Sept. 5, 1926, the head of the left femur was seen to be deeply placed in the acetabulum and there was intra-pelvic protrusion of the acetabulum. A similar degree of protrusio acetabuli was present on the right side, and several small cyst-like areas of rarefaction were seen in the upper margin of the acetabulum on this side, although at this time the symptoms were confined to the left side. The contour of the articular surfaces of both hip-joints were well preserved. The only alteration of radiographic

appearances observed up to the time of her first discharge in 1930 was a tendency to ' moulding ' or ' mushroom deformity ' of the left femoral head. This never became severe.

After discharge she was seen on several occasions, and, as the right hip was becoming progressively stiffer, she was re-admitted to the Sanatorium on Aug. 8, 1931. At this time she was much crippled. The movements of the right hip were restricted in all directions to less than 50 per cent of normal range. The left hip was fixed in a position of slight adduction, and in a neutral position as regards flexion and rotation. The right knee was somewhat swollen, suggesting synovial hypertrophy, and the left knee-joint was fixed. No definite X-ray changes were present in the knees. She was treated by T.A.B. injections and by massage and passive movement of the joints, and a slight improvement of mobility of the right hip and right knee resulted. She was discharged on Nov. 17, 1934, and when last seen in December, 1935, she was able to get about with the aid of sticks.

Frequent X-ray examinations had been made. These seemed to show a progressive improvement of the condition of the hips. The joint spaces, previously almost obliterated, reappeared, and the articular surfaces became more clearly defined. In the latest radiograph (*Fig.* 203), recalcification in the right hip has taken place, but some cyst-like areas of rarefaction are still present in the left femoral head. The protrusio acetabuli has not increased on either side during the eight years over which we have observed the patient. There is no further moulding of the femoral heads.

As an additional point of interest, this patient's father is crippled with some form of arthritis.

Protrusio acetabuli, or the ' Otto pelvis ', has been fully discussed by Pomeranz,[25] Golding,[26] and others. Golding recognizes three types of the condition: (1) Due to growth disturbances, often symptomless until the joint later becomes the seat of an arthritis; (2) Due to infective arthritis or osteo-arthritis of rheumatic type; (3) Due to destructive disease of the joint, e.g., pyogenic, syphilitic, or tuberculous arthritis, or to neoplasm. Schaap[27] points out that the condition is met with mainly in women, and that it is usually bilateral. He believes that most cases originate in early life, and that the joints may subsequently be affected by an arthritis. It seems that this has been the case in our patient (*Case* 9), for protrusio acetabuli was present on both sides at the first X-ray examination in 1926, even though there were no symptoms on the right side. The protrusion did not advance, and the only radiographic alterations observed over a period of eight years were general and localized rarefaction of bone (very like that observed in adult osteo-arthritis), narrowing of the joint space with subsequent restoration, and a slight ' moulding ' or flattening of the left femoral head. The arthritis also affected the knees, but recovery seems to be gradually taking place.

The girl was a tuberculous subject, a fact which caused confusion in the diagnosis. We believe, now, that she was suffering from a non-specific arthritis, and that the original protrusion of the acetabula was neither of tuberculous nor of arthritic origin.

6. Modification of the Course of Non-specific Arthritis due to Early Immobilization

There are, as yet, no certain rules governing the treatment of chronic non-specific arthritis. On the one hand, active exercise must be limited to prevent undue discomfort and exacerbation of the local disease, and on the other hand immobilization, unless under assiduous orthopædic control, is to be avoided as tending to promote early ankylosis and otherwise preventable deformity. We have already tentatively suggested (*Case* 1) that rest and the promotion of general

hygiene, as practised in sanatoria in this country, may delay the dissemination of an arthritis to other joints, but we have also shown that prolonged immobilization is detrimental to non-tuberculous arthritis of the hip. The cases that we shall now describe suggest that immobilization treatment may prevent or delay certain compensatory structural changes which are usually characteristic of the disease. These cases also present some unusual difficulties in diagnosis.

Case 10.—J. S., male, aged 18 years, was admitted to East Fortune Sanatorium on Nov. 8, 1933. In August of that year his left leg had become weak. This weakness was felt suddenly after a walk, and was followed by pain in the groin. In October he was sent to a hospital, where a diagnosis of tuberculous disease of the left hip-joint was made after an X-ray examination. He was then sent to the Sanatorium.

On admission he was in very poor condition, pale, thin, and weak. A presystolic mitral bruit was present. The blood sedimentation rate was increased, and he gave a strongly + reaction to the Mantoux test (1–1000). The blood Wassermann test was negative. The left hip was fixed in flexion at an angle of 45°, adducted and externally rotated, and any attempt at movement caused pain. X rays showed narrowing of the left hip-joint space and slight irregularity of the acetabulum. The right hip-joint was normal, but the left sacro-iliac joint showed appearances of definite disease. The diagnosis of tuberculosis was accepted and the left limb was placed in extension.

FIG. 204.—*Case* 10, Feb. 13, 1936. Arthritis was present in sacro-iliac, hip, and knee joints on both sides. Both hips and sacro-iliac joints are ankylosed, and the picture shows early bony trabeculation across the hip-joints, although the articular contours are well preserved. The case was thought to be one of spondylitis ankylopoietica.

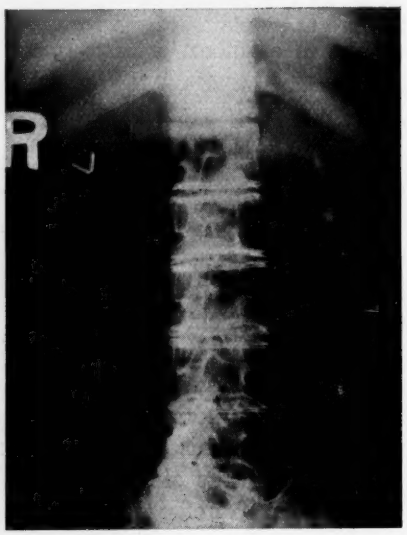


FIG. 205.—*Case* 10, Feb. 13, 1936. Atrophy of the vertebral bodies and almost complete loss of all the intervertebral disc spaces in the lumbar region. Ligamentous calcification was absent—a possible result of prolonged and early immobilization. Shadows of calcareous abdominal glands are to be seen.

By April, 1934, there were symptoms in the right hip and in both knees. The X-ray film now showed narrowing of the right hip-joint space, and in December, 1934, there was obliteration of both sacro-iliac joints. He had now disease of six joints—sacro-iliac, hip, and knee on both sides. The diagnosis of tuberculosis had been questioned in the early days of his treatment, but it was upheld for a time on account of the strongly positive tuberculin reaction, the presence of calcified glands in the abdomen, and of certain urinary symptoms. A month after his admission the patient had hæmaturia, which was repeated frequently during the following month. In February, 1934, an excretion pyelogram showed dilatation of the pelvis of the left kidney and alteration in the shape of the calyces. The urine contained a little albumin, but no pus and no tubercle bacilli. The hæmaturia was repeated in December, 1934, but did not persist.

He was eventually transferred to an orthopædic hospital, with no improvement in the physical condition of his joints, which even under a general anæsthetic were fixed. Dr. W. T. Munro investigated his urine and found a few pus cells, but guinea-pig inoculation with the deposit failed to produce tuberculosis. An X-ray film taken on Feb. 13, 1936, showed ankylosis of both sacro-iliac joints and of both hip-joints, with bony trabeculation commencing to show across the hip-joints (*Fig.* 204). The knees showed advanced general rarefaction of bone with 'stencilling' and loss of joint space. The lumbar and thoracic spine, in which there was very little movement, showed atrophy of the vertebral bodies and almost complete loss of all the intervertebral disc spaces (*Fig.* 205). In spite of the absence of calcification of the intervertebral ligaments, the case was now diagnosed as spondylitis ankylopoietica with involvement of the proximal joints of the lower limbs. A diagnostic arthrotomy of the right knee was performed in February, 1936. In this joint the synovial tissues were greatly proliferated and matted together, and there was pannus growth over the articular cartilages. Many histological sections were prepared from tissue removed from the synovial lining of the front of the joint and from the capsule on the inner side of the joint. The general pathological changes were atrophy of the synovial lining, fibrinous degeneration and fibrous-tissue replacement of the synovial tissues, obliterative endarteritis of vessels, and a scattered infiltration of lymphocytes, mononuclear cells, and a few polymorphs. There was no tubercle or giant-cell formation or caseation; neither were there focal collections of lymphocytes. No acid-fast bacilli were found.

Case 11.—A. R., male, aged 26 years, was admitted to East Fortune Sanatorium on June 17, 1933. During 1931 he had pain in the right leg which was called sciatica. After three weeks' rest the pain was relieved, and he resumed work. In December, 1932, he was compelled to give up work on account of pain in the lower part of the back. During the first months of 1933 he was seen as an out-patient at a general hospital. There was some doubt about the diagnosis, the changes shown in the X-ray film being called "infective arthritis or tuberculosis, probably the latter". On this statement, his doctor notified him as sacro-iliac tuberculosis.

FIG. 206.—*Case* 11, June 21, 1933. The sacro-iliac joints are diseased, a condition which was first thought to be tuberculous. There is no radiological abnormality of the hip-joints at this time, although there was limitation of movement of the right hip.

His general condition was fairly good when he came to the Sanatorium. The blood sedimentation rate was raised, and he gave a + reaction to the Mantoux test (1–1000). The Wassermann reaction was negative. He complained of pain in the back, and there was stiffness and rigidity of the lumbar spine. The left hip-joint moved normally. Movements of the right hip-joint were limited to a little passive movement in all directions. X-ray examination showed disease of both sacro-iliac joints, but no abnormality of either hip (*Fig.* 206). The diagnosis of bilateral sacro-iliac tuberculosis was accepted, and he was immobilized in a lumbar plaster. By April, 1934, the right hip-joint was fixed in a position of external rotation. Adduction had been prevented by the plaster. Extension was applied to the right

leg. In December, 1934, movements of the left hip were limited. Later both knees became stiff, and by the middle of 1935 he had exactly the same clinical and radiological condition as that described in *Case* 8—disease of both sacro-iliac joints, both hips, and both knees.

It is most interesting that he also had a similar renal condition. During June, 1934, he complained of pain in the left loin associated with nausea and vomiting. The left kidney was palpable and tender. The urine contained a small quantity of muco-pus, and pus cells and red blood-corpuscles were seen on examination of the deposit. Shortly afterwards he developed scarlet fever, and was transferred to a fever hospital. After his return in July, 1934, he again had loin pain, with similar symptoms, and the urine again contained a little albumin, pus, and red blood-cells. An excretion pyelogram showed pelvic dilatation of the left kidney, and the ureter appeared dilated in its upper course. The kidney was exposed for nephrectomy and was split and explored, but as it appeared quite healthy it was sutured in the usual way and replaced. There were no further urinary symptoms until December, 1935, when hæmaturia recurred, but lasted only a few days. Dr. Munro examined the urine and found a few pus cells in the smears. Guinea-pig inoculation failed to produce tuberculosis.

In March, 1936, the movements of the joints were tested under a general anæsthetic. The right hip was firmly fixed in a position of external rotation. The left hip had slight movement in all directions and adhesions were felt to yield during the manipulation of this joint. The knees had 15° to 20° of flexion movement, but without anæsthesia the patient was rigid from below the knees to the upper thoracic spine. A radiograph on Feb. 13, 1936, showed general loss of bone density and narrowing of the joint space of both hip-joints, and obliteration of the sacro-iliac joints (*Fig.* 207). The spine showed no ligamentous calcification, but irregularities of the lateral margins of the bodies of the 9th, 10th, and 11th thoracic vertebræ suggested early spondylitis (*Fig.* 208).

FIG. 207.—*Case* 11, Feb. 13, 1936. There is now definite evidence of non-tuberculous arthritis of both hip-joints. The right hip was ankylosed and the left hip had only a few degrees of movement when tested under a general anæsthetic. Both sacro-iliac joints are obliterated.

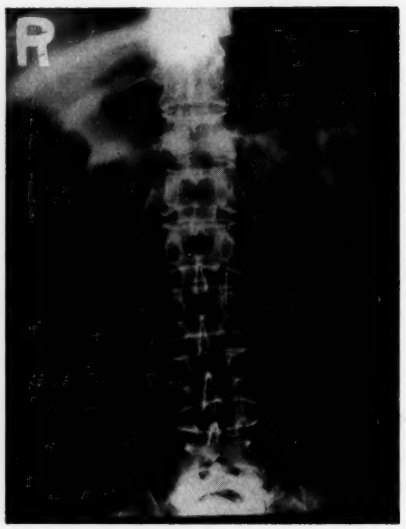


FIG. 208.—*Case* 11, Feb. 13, 1936. Irregularities of the lateral margins of the bodies of the 9th, 10th, and 11th thoracic vertebræ, together with the ankylosing disease of sacro-iliac, hip, and knee-joints on both sides, suggest spondylitis ankylopoietica. The patient was rigid from below the knees to the upper thoracic spine. No calcification of the vertebral ligaments is to be seen, but this result has possibly been prevented or delayed by the prolonged immobilization.

The correct diagnosis of these two cases (*Cases* 10 and 11) remained obscure for a considerable time. Finally, however, a diagnosis of spondylitis ankylopoietica was established as a result of a study of the literature, and as a result of comparison with another case which recently came to the notice of one of us (D. H. C.). We shall briefly describe this last case, because the symptomatology is rather unusual.

Case 12.—J. J. W., male, at the age of 15 suffered from an attack of arthritis affecting both knees and the right hip-joint. Recovery was apparently complete after a few weeks' rest in bed. At the age of 28 he noticed weakness and disability of the right hip without very much pain. This was not relieved, and in the following year symptoms appeared in the left hip. He received a course of gold injections without benefit, and then was admitted to an infirmary where both legs were placed in extension for five weeks. This treatment was followed by the application of a removable plaster, and massage was given daily for three months. The condition progressed and he was sent to the Harrogate Royal Bath Hospital on Jan. 16, 1936.

On admission there, it was found that both hips and the spine, excluding the cervical region, were quite rigid. The muscles of the thighs, gluteal regions, and back were much wasted. The knees were movable but very stiff. X-ray examination showed an infective type of arthritis of both hip-joints and of both sacro-iliac joints, exactly like the later pictures obtained in *Cases* 10 and 11. The diagnosis, in this case, was simplified by the presence of lateral bridging due to ligamentous calcification, between the 12th thoracic and 1st lumbar, and between the 1st and 2nd lumbar vertebræ (*Fig.* 209). The suspicion of visceral tuberculosis was absent in this case, and he gave no reaction to the first test dose of Tuberculin P.P.D.

Physical and bath treatment enabled him to walk with the aid of two sticks. Pain was relieved, and the adoption of an upright posture restored free movement to his knees. It is doubtful whether progressive ankylosis of the spine and hips can be altogether prevented.

FIG. 209.—*Case* 12, Jan. 27, 1936. Spondylitis ankylopoietica. Calcification of the lateral vertebral ligaments is here shown between D. 12 and L. 1, and between L. 1 and L. 2 vertebræ. The condition of the hips and sacro-iliac joints was identical with that of these joints in *Cases* 10 and 11, but this patient had not been subjected to prolonged immobilization.

The pathological differentiation of the earlier known cases of spondylitis was made by Knaggs,[28] but owing to the scarcity of post-mortem material, which often shows only advanced changes, much of our knowledge of the early stages of this very chronic disease has come from the radiologists. Thus, Scott[29] has shown that every one of his 110 cases of 'spondylitis adolescens' had a bilateral affection of the sacro-iliac joints, usually in the form of ankylosis, which may commence some years before the onset of spinal signs or symptoms. Scott is also of opinion that the sacro-iliac infection may cease at any time and never become a spondylitis. Golding[30] confirms that sacro-iliac disease always precedes spinal changes, and he has experience of two instances in which the hip-joints were attacked early with a severe onset and much pain. M. P. Weil[31] states that the intervertebral discs are often diminished in height, as in our *Case* 10. Forestier[32] recognizes that the disease may be active up to five years before the onset of ligamentous calcification. Knaggs[28] writes that in the *rhizomélique* form of spondylitis (Pierre-Marie) pain is often located in the lumbar region or in the hips, and that the hips become affected when the disease is active in the lumbar region. Golding mentions the occasional involvement of the knee-joints, and we have observed this in other cases apart from those we have just described.

Two of our patients (*Cases* 10 and 11) were immobilized for long periods, and although certain abnormalities were revealed radiographically in the vertebral column, neither patient has yet developed ligamentous calcification. Buckley,[33] in an excellent paper on ankylosing spondylitis, makes it clear that calcification of the vertebral ligaments is a defensive reaction designed to counteract the effect of the softening and rarefaction of the vertebral bodies and thus to prevent serious spinal collapse and deformity. The chronic course of the disease allows ample time for this defence reaction to take place. Immobilization treatment adopted in our two cases may well have provided sufficient spinal support to delay the pathological reinforcement of the spinal ligaments. Whether this treatment and its effect are totally beneficial remains to be determined by further experience. In our cases it did not prevent the centrifugal spread of the arthritis from sacro-iliac to hip and knee joints.

The early diagnosis was confused, in *Cases* 10 and 11, by the absence of calcification of the vertebral ligaments, by the early affection of the hips, by the positive tuberculin reactions, and by the occurrence of hæmaturia. We are satisfied that this hæmaturia was not due to genito-urinary tuberculosis, and we can only offer the suggestion that tumefaction around the sacro-iliac joint had caused partial obstruction to the outflow of urine from the left kidney in each case. In *Case* 11 the pyelogram revealed dilatation of the upper course of the left ureter as well as of the left renal pelvis.

The question of the ætiology of the spondylitis and arthritis in these cases remains to be considered. Knaggs[28] believed a toxic factor to be the cause of ankylosing spondylitis, and it is clear from recent researches that the condition is an infective one of a type similar to rheumatoid arthritis. Gonorrhœa was once considered to be the commonest cause, but many other organisms have now been incriminated. Certain authorities, including Weil[31] and Forestier[32], regard tuberculosis as a possible infective factor in the production of spondylitis, and Buckley, while not subscribing to this view, found that 15 out of 18 of his cases gave a positive tuberculin reaction. Alajouanne and Lacapère[34] consider that the evidence for a tuberculous origin is not irrefutable. Be that as it may, ankylosing spondylitis is so clearly a clinical entity and is at such pathological variance with ordinary tuberculous arthritis that its differentiation from the latter in the early stages remains a matter of great importance.

7. The Possibility that there Exists an Atypical Tuberculous form of Polyarthritis—Tuberculous Rheumatism

In 1897, Poncet of Lyons first described the clinical picture of tuberculous rheumatism, and launched a controversy which has persisted, mainly in French medical literature, ever since. In the same year J. Stewart[35] of Montreal wrote: "Indirectly a tuberculous tendency may, by lowering the resistance, tend to bring about a rheumatoid arthritis, and it is only in this sense, as I understand it, that there is a connection between the two diseases". Poncet and his school later sought a tuberculous origin for many different forms of arthritis. Around these divergent views the controversy has continued, with little convincing proof on either side, and little attempt at compromise until recent years. Cases described by Bezançon, Bernard, Oumansky, and Gaucher,[17] Laederich, Mamon, Arager

and Léonard,[36] Rathery and Doubrow,[37] and Le Sage,[38] and essays by Ory[39] and Weil,[40] define, more clearly than earlier works, the limitations of the condition which French authors consider to be tuberculous rheumatism.

Under this designation there appear to be two types of disease. The first resembles acute rheumatism, in that the joints are successively affected without permanent lesion or disability, but differs from rheumatic fever in the absence of cardiac involvement and in its resistance to salicylate therapy. This type has been ascribed to a filterable or otherwise altered form of the tubercle bacillus, or to an allergic condition secondary to a visceral tuberculous infection. The second type is that of a transitory or more chronic polyarthritis eventually becoming localized in one of the joints earlier affected. Tubercle bacilli have usually been isolated from the joint in which the infection appeared to localize. In such a case, however, as in our *Case* 4, we cannot be certain that a true tuberculous arthritis has not been superimposed upon a polyarthritis of other ætiology.

Medical authors in this country have paid very little attention to the question. Cases of polyarthritis in tuberculous subjects, which had some points in common with the French cases, have been described by Raw[41] and Copeman and Clay.[42] For a time, the finding of tubercle bacillæmia by Reitter and Löwenstein[43] in many cases of polyarthritis seemed to favour the concept of a tuberculous rheumatism, but negative observations by many other workers, and criticisms[44] of the technique employed in the original investigations, have belittled the importance of this finding. An excellent and full review of the subject of tuberculous rheumatism has been undertaken by Brav and Hench,[21] who conclude that there is still no incontrovertible proof of the existence of such an entity as tuberculous rheumatism.

The cases which we have described include a variety of arthritic manifestations occurring in tuberculous subjects. Every investigation and observation that we have been able to make has led us to the conclusion that, with the exception of *Cases* 4, 5, and 6, none of these patients suffered from a true tuberculous arthritis. We cannot categorically deny the possible influence of associated visceral tuberculosis on the production and course of the joint disease, but we prefer not to use the term 'tuberculous rheumatism' for the following reasons: (*a*) Every case pursued a course consistent with non-specific arthritis; (*b*) Immobilization treatment, adopted on the suspicion that the condition was tuberculous, proved to be a totally unsuitable procedure in each case.

SUMMARY

The cases of 12 patients suffering from various forms of arthritis have been described. In 11 patients the arthritis was multiple. In 11 patients tuberculosis was suspected, and in 8 visceral tuberculosis was proved. The arthritis in 9 instances was finally not considered to be tuberculous. Six patients were wrongly diagnosed, in the first place, as tuberculous arthritis, and the detrimental effect of treatment adopted on this diagnosis has been recorded. Three early cases of spondylitis ankylopoietica with unusual symptomatology have been included.

The cases have been utilized to illustrate the difficulties in the early diagnosis of tuberculous arthritis and to warn against the too ready acceptance of a tuberculous etiology in multiple arthritis occurring in presumably tuberculous subjects.

The facts which add confusion to the diagnosis of such cases, and which have been discussed and exemplified, are the following:—

1. The insidious monarticular onset of some cases of multiple non-specific arthritis.

2. The coexistence in the patient of some visceral tuberculous lesion, which may or may not influence the course of a non-tuberculous polyarthritis.

3. The possible occurrence of a single tuberculous joint superimposed upon a non-tuberculous multiple arthritis.

4. The occasional incidence of a true tuberculous arthritis in two or more joints.

5. The comparative infrequency of non-specific arthritis of the hip in patients under middle age, and the tendency to suppose such a condition to be tuberculous.

6. Modification of the course of a non-specific arthritis due to early immobilization.

7. The possibility that there exists an atypical tuberculous form of polyarthritis—tuberculous rheumatism.

We believe that confusion in diagnosis in this type of case is not uncommon, and that many other cases of non-specific arthritis may have been subjected to prolonged and expensive immobilization treatment prejudicial to their subsequent recovery of function.

We suggest that in all such cases expectant treatment should be adopted. This should consist of maintenance of general hygiene, and rest in bed without immobilization until unequivocal evidence of the tuberculous or non-tuberculous nature of the joint disease appears, or is obtained by examination of aspiration or biopsy material.

We wish to thank the following physicians of the Harrogate Royal Bath Hospital for access to their patients: Dr. Dorothy Potter (*Case* 1), Dr. Geoffrey Holmes (*Case* 4), Dr. Nimmo Watson (*Case* 7), and Dr. Alfred Sharp (*Case* 12); and we record our gratitude to Dr. W. T. Munro of Glenlomond, Kinross, for his kindness in examining and culturing the urines of *Cases* 10 and 11.

REFERENCES

[1] SMITH, A. DE F., and WATTERS, W. H., *Jour. Amer. Med. Assoc.*, 1928, xc, 189.
[2] SMITH, A. DE F., *Arch. of Surg.*, 1932, xxv, 54.
[3] MILGRAM, J. E., *Jour. Amer. Med. Assoc.*, 1931, xcvii, 232.
[4] GHORMLEY, R. K., and BRAV, E. A., *Arch. of Surg.*, 1933, xxvi, 465.
[5] ALLISON, N., and GHORMLEY, R. K., *Diagnosis in Joint Disease*, 1931. London.
[6] GIRDLESTONE, G. R., *Brit. Jour. Surg.*, 1931–32, xix, 488.
[7] FORRESTER-BROWN, M., *Ibid.*, 1930–31, xviii, 54.
[8] FRASER, J., *Tuberculosis of the Bones and Joints in Children*, 1914. London.
[9] ROGERS, M. H., *Jour. Bone and Joint Surg.*, 1922, N.S. iv, 679.
[10] SMITH, A. DE F., *Jour. Amer. Med. Assoc.*, 1924, lxxxiii, 1569.
[11] PHEMISTER, D. B., *Ann. of Surg.*, 1924, lxxx, 481.
[12] PHEMISTER, D. B., *Jour. Bone and Joint Surg.*, 1925, N.S. vii, 835.
[13] PHEMISTER, D. B., and HATCHER, C. H., *Amer. Jour. Rœntgenol.*, 1933, xxix, 736.
[14] POMERANZ, M. M., *Ibid.*, 1933, xxix, 753.
[15] HENDERSON, M. S., and FORTIN, H. J., *Jour. Bone and Joint Surg.*, 1927, N.S. ix, 700.
[16] ATSATT, R. F., *Ibid.*, 657.
[17] BEZANÇON, F., BERNARD, E., OUMANSKY, and GAUCHER, *Bull. et Mém. Soc. méd. Hôp. de Paris*, 1931, lv, 742.

[18] LONG, E. R., SEIBERT, F. B., and ARONSON, J. D., *Tubercle*, 1935, xvi, 304.
[19] COLLINS, D. H., *Jour. Pathol. and Bacteriol.*, 1936, xlii, 113.
[20] PEMBERTON, R., *Arthritis and Rheumatoid Conditions*, 1935. London.
[21] BRAV, E. A., and HENCH, P. S., *Jour. Bone and Joint Surg.*, 1934, N.S. xvi, 839.
[22] FORESTIER, J., *Rev. du Rhumatisme*, 1936, iii, 53.
[23] FORRESTER-BROWN, M., *Lancet*, 1935, i, 1377.
[24] TELFORD, E. D., *Ibid.*, 1934, ii, 823.
[25] POMERANZ, M. M., *Jour. Bone and Joint Surg.*, 1932, N.S. xiv, 663.
[26] GOLDING, F. C., *Brit. Jour. Surg.*, 1934–35, xxii, 56.
[27] SCHAAP, C., *Jour. Bone and Joint Surg.*, 1934, N.S. xvi, 811.
[28] KNAGGS, L., *Brit. Jour. Surg.*, 1924–25, xii, 524.
[29] SCOTT, S. G., *Brit. Jour. Radiol.*, 1936, ix, 127.
[30] GOLDING, F. C., *Brit. Jour. Surg.*, 1935–36, xxiii, 484.
[31] WEIL, M. P., *Rev. du Rhumatisme*, 1935, ii, 525.
[32] FORESTIER, J., *Ibid.*, 472.
[33] BUCKLEY, C. W., *Reports on Chronic Rheumatic Diseases*, 1935, i, 77.
[34] ALAJOUANINE, T., and LACAPÈRE, J., *Rev. du Rhumatisme*, 1935, ii, 390.
[35] STEWART, J., *Brit. Med. Jour.*, 1897, ii, 1225.
[36] LAEDERICH, L., MAMON, H., ARAGER, and LÉONARD, *Bull. et Mém. Soc. méd. Hôp. de Paris*, 1931, lv, 1836.
[37] RATHERY and DOUBROW, *Ibid.*, 1934, lviii, 13.
[38] LE SAGE, A., *Ibid.*, 284.
[39] ORY, *Acta Rheumatologica*, 1932, iv (No. xiv), 8.
[40] WEIL, M. P., *Rev. belge Sci. méd.*, 1933, v, 658.
[41] RAW, N., *Proc. Roy. Soc. Med.*, 1914, vii (2), (Med. Sect.), 68.
[42] COPEMAN, W. S. C., and CLAY, R. D., *Lancet*, 1935, ii, 1460.
[43] REITTER, C., and LÖWENSTEIN, E., *Wien. klin. Woch.*, 1934, xlvii, 1569.
[44] SIEGEL, M., *Amer. Jour. Med. Sci.*, 1935, cxc, 345.

GRAVITY DRAINAGE OF PELVIC ABSCESS

By A. LEE McGREGOR

ASSISTANT SURGEON, JOHANNESBURG GENERAL HOSPITAL
LECTURER ON SURGICAL ANATOMY, UNIVERSITY OF THE WITWATERSRAND

THIS paper has for its object the determination of *precisely* what place the rectal or vaginal drainage of abscesses in the pouch of Douglas should occupy in surgery. It seems fair to say that to the average practitioner this operation presents itself as a simple, safe, and eminently satisfactory procedure. That this is emphatically not the case it is the purpose of this communication to show.

THE LITERATURE

MacLaren[1] (1908) gave the opening paper in a symposium dealing with the question of purulent collections in the pelvis. He stated that the problem had been solved in the female, in whom such cases could be cured by section per vaginam. He drew attention to the great importance of catheterizing the patient before opening an abscess through the rectum, and mentioned a case where he opened the bladder in error through omitting this precaution. Although the abscess was opened also, the patient recovered. He was the first to give the warning that dangerous bleeding might occur through division of a branch of the superior hæmorrhoidal artery in the rectal wall. He advised that in all cases of diffuse septic peritonitis, after the third day, whether the rectal wall was bulging or not, an incision should be made into it, a finger inserted, and the pelvis explored for pus. He terminated his address by saying: "And what is the danger of rectal drainage? None at all according to a limited experience." These remarks were generally agreed to in the ensuing discussion.

Ritchie[2] (1918) states that any uncertainty of diagnosis whether there exists an abscess into the pouch of Douglas should lead to postponement of the operation of rectal drainage or the use of other measures. The operation should be strictly limited to cases with a well-defined mass per rectum. Here also the advice is given to drain away the exudate in general peritonitis by rectal incision. Obviously at the dates quoted the pathology of the peritoneal exudate was not appreciated.

Ritchie stated, moreover, that the operation should be confined to males and children, as it presents no advantage over section per vaginam. He says emphatically that the dangers and risks of rectal drainage are not to be considered, because of the usually imperative circumstances. He drew attention to the important fact that because of the adjacent inflammation the patient could not completely empty the bladder, making pre-operative catheterization more imperative than ever.

Moynihan[3] (1918) wrote that an abscess which bursts into the rectum or vagina drains very freely and closes more rapidly than if drained from above. He used the rectal route on three occasions in conjunction with a suprapubic drain, and stated that healing was much more rapid than it would have been if only one incision had been used.

Carson[4] (1924) stated that discharge ceases quickly after rectal drainage has been instituted, and that it is characteristic of these cases that recovery is rapid. He also stated that the small intestine is pushed up by the collection of fluid and that there is little risk of its being injured. He said: "I have never known any accident happen as a result of the rectal incision."

Blake[5] (1928) expresses a sharply contrary opinion: "Pelvic abscesses in the male are best drained, as a rule, by suprapubic incision; exceptionally they may be drained by *perineal incision*, the dissection being carried up between the rectum and the prostate. These abscesses can be drained into the rectum, but this procedure is objectionable; therefore it is often unsatisfactory and the dressings are painful.

Hamilton Bailey[6] (1930) says that twenty or thirty years ago drainage of pus per rectum was extensively done, but the practice has fallen into disfavour and has now been almost entirely supplanted by suprapubic drainage. The reasons for the change which he gives are, firstly, that a loop of obstructed small gut in the retrovesical pouch may be mistaken for a collection of pus, and, secondly, that a pelvic collection of pus does not necessarily mean that this collection is shut off by adhesions in the pelvis. He stigmatizes the procedure as a blind one which has justly earned the reputation of being dangerous. Blind rectal drainage should therefore be reserved for those cases where the history, the free discharge of mucus, the soft cystic swelling, and complete absence of rigidity, make the diagnosis of a localized abscess pointing in the rectum undeniable. If the slightest doubt exists, laparotomy should be done. Should this disclose an abscess localized in the pelvis, he advises closure of the suprapubic wound and rectal drainage.

Kirschner[7] (1933) says that abscesses in the pouch of Douglas are preferably opened through the rectum or vagina.

Burnett[8] (1934) states that this procedure fell into disrepute because it is a blind procedure and cases were not carefully chosen. There are times when this procedure may save the patient, who would die from the toxæmia of an infection too slowly relieved by uphill suprapubic drainage. He points out that abdominal drainage is a major procedure, with its risks of anæsthesia, shock, and the spread of infection. Rectal or vaginal drainage is a brief minor procedure in proper cases and avoids most dangers. He says that the rectal wound tends to close in two or three days and the finger must be inserted daily to avoid this.

CASE REPORTS

Of 10 cases of pelvic abscess drained per rectum or vaginam, 7 cleared up rapidly and uneventfully. Three cases were followed by serious complications. These three patients died. In two of these cases, however, complications following drainage of the abscess were not the only causes contributory to the final issue.

Case 1.—L. K., married, age 34. Patient was a small frail woman who complained of lower abdominal pain and ill health for some weeks. Ultimately a P.V. examination disclosed a cystic swelling in the pouch of Douglas. At this time the temperature was 102°, the pulse 110, and the white blood-count was 15,000 with 85 per cent polymorphs.

Under general anæsthesia a needle was passed into the bulging posterior fornix and thick creamy pus aspirated. A knife was passed into the swelling in the mid-line. Much creamy fluid escaped mixed with hair, and lastly a coil of small bowel prolapsed into the vagina. The opening into the vaginal vault was sutured after the gut had been returned into the peritoneal

cavity, and abdominal section was performed at once. The collapsed dermoid cyst was removed, a pelvic appendix lying in a cavity of encysted pus was removed, and the abdomen was drained by the suprapubic route. The patient slowly developed the rare condition of extra-peritoneal cellulitis, which resulted in pockets of pus forming in the extra-peritoneal fat till ultimately the outer surface of the perifoneum was surrounded with pus cavities. After a lingering illness of six months' duration the patient died.

Comment.—In this case the diagnosis was at fault. All the signs indicated abscess formation; the cystic swelling filled the pelvis, the exploring needle showed pus-like fluid. Lowered resistance in a frail unhealthy woman supplied the other factors necessary for the extensive spread of the infection, once the integrity of the peritoneum was disturbed by the opening of the parametric cellular tissue when the cyst was removed.

Case 2.—M. L., aged 27. Patient was admitted to the Johannesburg General Hospital under my care suffering from acute obstructive appendicitis. The appendix was removed intact. Drainage was not used. On the eighth post-operative day the temperature, which had been normal for six days, began to rise. The lower abdomen became tumid. Mucus was present in the stools, a pelvic collection could be felt per rectum. The patient's general condition was low. It was resolved to wait until an abscess bulged the rectal wall, which state of affairs obtained three days later.

Operation was performed with the patient in the lithotomy position, the bladder having been emptied by catheter. The anterior rectal wall tensely bulged into the lumen of the bowel. It was punctured with a Christopher Martin trocar, the opening being enlarged by inserting one finger. About two pints of foul-smelling pus were evacuated. The finger was put into the rectum to feel if everything was satisfactory, when a soft structure was detected. Examination with a speculum showed this to be *a knuckle of small bowel*. It was quite impossible to rectify this through the anus. An immediate abdominal section had to be done in a patient already much reduced by suppuration in the abdomen.

Operation was rendered notable by two unusual features:—

1. It was only with the greatest difficulty that the pelvic abscess cavity could be found, as the gut was matted in a dense roof extending across the pelvic brim.

2. Between this roof and the right side of the pelvic brim existed a fissure through which a loop of bowel extended, this loop lying on the pelvic floor, i.e., forming part of the contents of the abscess cavity. It was this loop which prolapsed into the rectum. Filmy adhesions prevented pus from the abscess escaping into the general peritoneal cavity alongside the loop of bowel which was prolapsed through the fissure which has been described. Because of the matting together of the intestines, the technical difficulties, and the seriously depleted general health of the patient, it was considered advisable to cover the hole in the rectum with gauze packing, several yards being necessary. The end of the plugging was brought through a suprapubic stab for drainage purposes. This plugging was slowly removed between the sixth and eighth post-operative days. There was no further protrusion of the bowel into the rectum, but a fæcal fistula had developed. The patient was unable to overcome the infection, dying from weakness due to continued suppuration a month after operation. Knowing the matted state of the abdominal contents it was considered inadvisable to do a colostomy. In this case rectal drainage of a pelvic abscess ultimately caused the death of the patient.

Comment.—This case is noteworthy. No record of a similar case can be found in South African medical libraries. There seems no reason to doubt that a loop of small gut lay in the pelvis *in an abscess cavity bathed in pus*, yet functioned normally. There was nothing whatsoever to indicate this state of affairs before operation. The only way it could have been demonstrated would have been by radiography and following the barium through the bowel. Furthermore, it seems that if and when pelvic abscesses are drained per rectum or vaginam a complete barium examination should precede the drainage. If bowel (excluding the rectum) is seen in the pelvis, rectal or vaginal drainage is contra-indicated.

Case 3.—C. F. B., surgeon. This patient was operated on by Mr. Dauth for recurrent attacks of colic, an upper abdominal mass being present. A carcinoma of the transverse colon was disclosed. Carcinoma cells had carried infection through the bowel wall, an abscess being enclosed by omentum, transverse mesocolon, and small bowel. The affected loop of colon was delivered and the wound closed. The exposed bowel was removed with the cautery next day.

The patient slowly went downhill—the wound suppurated and gaped, and a jejunal fistula formed. He developed a large pelvic abscess, and there was three-quarters of an inch of tissue between the lumen of the rectum and the abscess cavity; a tube was fixed in the cavity by a stitch at the anal margin. This caused excruciating pain and ultimately a peri-anal abscess. The patient, a brilliant surgeon, stated during his illness that silkworm gut should never be used in infected tissues because it was too rigid and caused too much pain, and that the tube draining a pelvic abscess should never be fixed with a stitch.

It was found necessary to reopen the drainage track with the finger on several occasions as it tended to close. Within two days of the initial drainage of the abscess an intensely painful acute cystitis developed. This caused the most excruciating suffering, due to the contraction of the inflamed thickened bladder wall. The patient died after a protracted illness, during which fearful agonies were borne with unexampled fortitude.

Comment.—In this case it was entirely impossible to utilize any other method of drainage than per rectum. The state of the abdominal wall and the precarious condition of the patient alike precluded abdominal section. The noteworthy features of the pelvic abscess were the thick wall which constantly closed the drainage hole, and the spread of the infection through the bladder wall, causing cystitis. The peritoneum acts as an able localizing agent, but once the peri-vesical connective tissue became infected where it was exposed in the drainage track, the infection was able to reach the bladder and spread through its wall and cause cystitis. This spread was by direct extension. Frequency of micturition, dysuria, and diarrhœa are classical symptoms of pelvic abscess, being due to the irritation of bowel and rectal walls by hyperæmia as they form part of the periphery of the abscess. It is surprising how rare a frank cystitis is in cases of pelvic abscess.

In this case the rectal drainage of the abscess led to a painful complication but was not responsible for the patient's death.

DISCUSSION

No mention so far has been made of the cases of pelvic abscess which do well after rectal or vaginal drainage. No object will be served by giving case histories, but there is one factor of supreme importance which was common to all cases, the ages varying from 4 to 70 years, this factor being that none of these patients were gravely ill. True, all had had a serious illness—acute appendicitis with localized peritonitis; but all had rapidly got better of the infection and looked and felt well despite the existence of an abscess. It seems correct, then, to say that a patient who is gravely ill is suitable soil for the implantation of some serious or fatal complication following the making of a drainage opening anywhere, whether this be suprapubic, vaginal, or rectal.

The most serious complication which may ensue on pelvic drainage is presented by the small bowel. Had the loop of bowel lying on the pelvic floor in *Case* 2 been adherent to the anterior surface of the rectum it might quite well have been opened by the trocar. The lesson to be learnt from the case is that only by X rays can the presence of such a dependent loop be demonstrated. Though the complication is rare, it is serious, as the prolapse of the small bowel into the rectum will almost

certainly lead to a fatal issue. It is of the first moment to observe that abdominal section may fail to disclose the fact that a loop of small bowel is lying on the floor of the pelvis (*Case* 2). This measure, therefore, is not an absolute safeguard against injury to the bowel during the process of instituting gravity drainage. It follows that cases of pelvic abscess suitable for rectal drainage should have careful X-ray examination first wherever this is possible. If the patient is too ill, as sometimes happens, then he is certainly too ill for any but rectal drainage, and the attendant risks must be taken.

As the result of the foregoing analysis, the following facts emerge :—

1. Rectal or vaginal drainage of a pelvic abscess is a valuable therapeutic measure.

2. In by far the greater number of cases the operation is followed by no ill effects and recovery is prompt.

3. In persons already gravely ill the procedure may be followed by cystitis, extra-peritoneal cellulitis, etc. Yet this is the very type of case where the indications for gravity drainage are the least contentious.

4. The two main risks are : (*a*) Mistakes due to faulty diagnosis ; (*b*) Injury to the small bowel.

5. If the diagnosis is the least in doubt, then abdominal section is necessary, followed if indicated by gravity drainage per rectum or vaginam.

6. Extremely rarely the small bowel may herniate through the drainage opening. Should it prolapse into the vagina there is not much harm done providing the emergency is promptly and suitably dealt with. Should the prolapse occur into the rectum, the issue is likely to be fatal.

There are certain negative rules :—

1. *Never* drain per rectum or per vaginam if the diagnosis is in doubt, without preliminary abdominal section.

2. *Never* perform the operation unless the catheter has been passed on the table.

3. *Never* drain through any but an opening exactly median in position.

4. *Never* stitch the drainage material to the anus.

5. *Never* drain below if the abscess in the pelvic cul-de-sac bulges into rectum or vagina on one side only. The abscess which admits of gravity drainage must bulge the rectum or posterior fornix in the midline, i.e., it must be large enough to fill the pouch of Douglas completely.

If the occasional execution of an innocent person is no argument for the abolition of capital punishment, then, surely the very occasional occurrence of a serious complication following gravity drainage of a pelvic abscess should not be permitted to condemn a procedure which is usually simple, expedient, and eminently satisfactory.

REFERENCES

[1] MacLaren, A., *Surg. Gynecol. and Obst.*, 1908, vi, 671.
[2] Ritchie, H. P., *Jour. Amer. Med. Assoc.*, 1918, Aug. 10.
[3] Moynihan, Sir B., *Abdominal Operations*, 1918, ii, 179. London.
[4] Carson, H. W., *Modern Operative Surgery*, 1924, ii, 28. London.
[5] Blake, J., *Nelson's Loose-leaf Surgery*, v, 32.
[6] Bailey, Hamilton, *Emergency Surgery*, 1930, ii, 28. Bristol : John Wright & Sons.
[7] Kirschner, Martin, *Operative Surgery* (The Abdomen and Rectum), 1933, 341.
[8] Burnett, W. E., *Surg. Clin. N. Amer.*, 1934, xiv, No. 1, 155.

MYOMATA OF THE ŒSOPHAGUS

By J. DUDFIELD ROSE
DEPARTMENT OF PATHOLOGY, UNIVERSITY OF DURHAM COLLEGE OF MEDICINE

SIMPLE tumours of the œsophagus—lipoma, fibroma, adenoma, papilloma, and the various cystic epithelial tumours—are all rare. These tumours are as a rule small, they do not cause symptoms, and are usually chance findings at autopsy. The clinical insignificance of these growths, and the lack of features of special pathological interest, are no doubt factors in the comparative infrequency with which such tumours are recorded. The following case of multiple myomata of the œsophagus is deemed worthy of report as the clinical symptoms were marked and the tumours were the primary cause of the death of the patient.

CASE REPORT

A man aged 74 years was admitted to the Royal Victoria Infirmary, Newcastle-upon-Tyne, as an emergency suffering from severe dysphagia and asthenia. He was in such a weak condition that no satisfactory history could be obtained, and a palliative gastrostomy was performed by Mr. Andrew Logan after a diagnosis of carcinoma of the œsophagus had been made. His general condition showed progressive deterioration, and death occurred three and a half days later. Owing to his physical state, no radiological or laboratory investigations were made. Attempts to obtain a proper clinical history from the patient's medical attendant failed, as the latter did not reply to the inquiry.

POST-MORTEM EXAMINATION.—This was performed six hours after death. The body was extremely wasted and dehydrated. The following is a summary of the findings :—

Stomach.—Fresh easily broken-down adhesions present between the stomach and the anterior abdominal wall in the region of the left costal margin. The organ was of normal size, with some slight thickening of the mucosa, and early post-mortem digestion over the fundus. On the lesser curve, some 6 cm. from the pylorus, were three healed linear scars. The pylorus was slightly narrowed by a small rounded nodular tumour in the posterior wall which, on section, showed a fasciculated structure suggestive of myoma or adenomyoma. Anterior gastrostomy opening healthy, no leakage.

Pleural Cavities.—Numerous dense old adhesions on both sides, especially at the right base ; cavities practically dry.

Trachea.—Full of a brownish froth ; mucosa roughened and injected.

Left Lung.—Showed small areas of broncho-pneumonic consolidation throughout. The apex was a mass of scar tissue, and scattered in this were several pea-sized active phthisical cavities.

Right Lung.—Showed small areas of broncho-pneumonic consolidation as in the left, with congestion and a little œdema. The upper lobe was hard and solid and studded with small rounded greyish nodules of active tuberculosis.

Pericardium.—Healthy, no excess of fluid.

Heart.—Normal size, dilated right side, aortic and mitral valves show some thickening with a little fibrosis of the tips of the papillary muscles. Myocardium a little softened ; coronary vessels healthy ; the first part of the aorta had a slight degree of atheroma.

Liver.—No abnormal features apart from some toxic swelling and pallor.

Gall-bladder.—Contained about 60 to 70 mixed faceted stones of various sizes.

Suprarenals.—No obvious pathological change.

Kidneys.—Not reduced in size ; slight senile atrophy, but no signs of renal lesions ; pelvis slightly dilated, no inflammation.

Bladder.—Muscular wall was hypertrophied and showed many trabeculæ; mucosa a little hyperæmic; ureters—slight generalized dilatation.

Prostate.—Slightly enlarged throughout, very nodular; on section, white and meaty, suggestive of carcinoma.

Spleen.—Rather small; sugar-icing thickening of capsule; adherent to diaphragm; somewhat atrophic on section, with prominent fibrous trabeculæ.

Œsophagus.—Externally the œsophagus was not unduly adherent to the mediastinal structures, but the lower end was thickened, and in the posterior wall of the middle third several small discrete hard rounded swellings were felt. It was laid open along its posterior

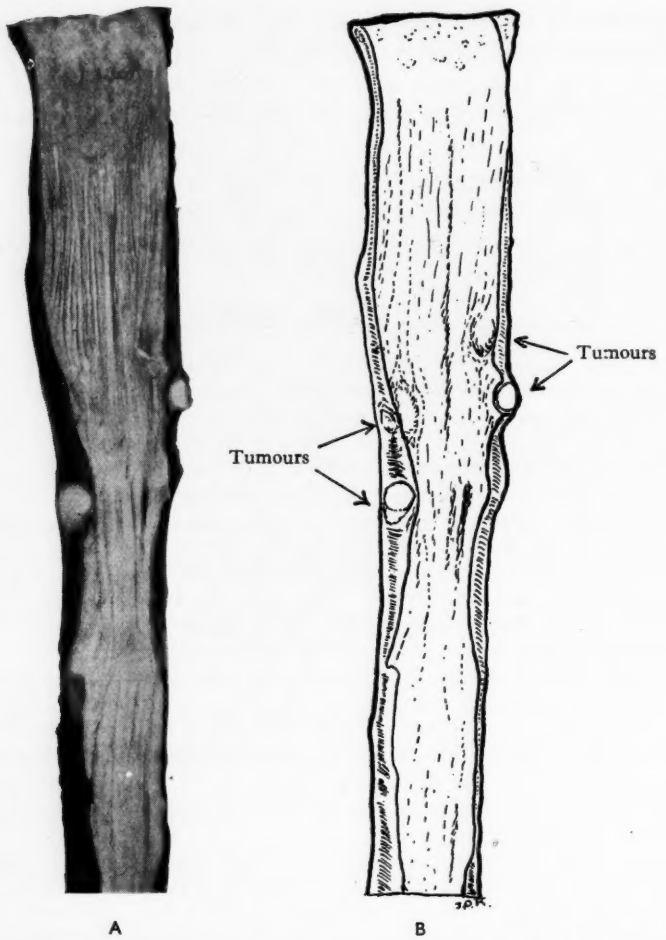


FIG. 210, A, B.—Œsophagus laid open posteriorly. Two of the tumours are seen interrupting the continuity of the circular muscle coat. The dilatation above the growths is indicated by the linear folds of the mucosa. The hypertrophy of the circular muscle below the tumours is clearly seen. The distal 3 cm. of the œsophagus is not shown.

aspect, dissected up from the trachea and pericardium, and pinned out for fixation in 10 per cent formalin saline (*Fig.* 210, A, B). The fixed specimen, including the distal 2 cm. which had been removed with the stomach, was 30 cm. in length. Four small, nearly spherical nodules were situated at the junction of the upper and middle thirds, the most proximal being 9 cm. from the cricoid, the remainder within the next 3 cm. Of the four nodules, three were spherical, with diameters of 0·5, 0·7, and 0·8 cm.; the other was slightly elongated in the length of the œsophagus, and measured 0·8 × 0·6 cm. The tumours were hard, of almost cartilaginous consistency, and the cut surfaces were greyish-white in colour with a watered

silk appearance, sharply contrasting with the brownish muscular coats. They were all situated in, and interrupted the continuity of, the circular muscle. The tumours were not adherent to the mucosa or submucosa, which were freely movable, and the mucosa appeared healthy throughout, apart from a slight hyperæmia in the immediate vicinity of the growths. The œsophagus at the upper end had a normal circumference of 4 cm. At the level of the first nodule it had decreased to 3 cm., this being further reduced to 2·7 cm. at the most distal nodule. It was noted that the mucosa between the cricoid and the first tumour was redundant and thrown into many more longitudinal folds than are usually found, indicating that during life there had probably been here some degree of dilatation. Just beyond the lowest nodule the diameter of the œsophagus narrowed down to 2 cm., after which it again increased to 2·7 cm. for a further 4 cm. before narrowing to 1·8 cm. just above the cardiac opening. At the upper end the circular muscle coat measured 0·2 cm. in thickness, while at the cardiac end it was 0·7 cm. The longitudinal muscle was of a uniform thickness of 0·15 cm. throughout.

Microscopical examination of the tumours (*Figs.* 211–214) showed that they had the structure of pure myomata, being composed of bundles of smooth muscle fibres running in all

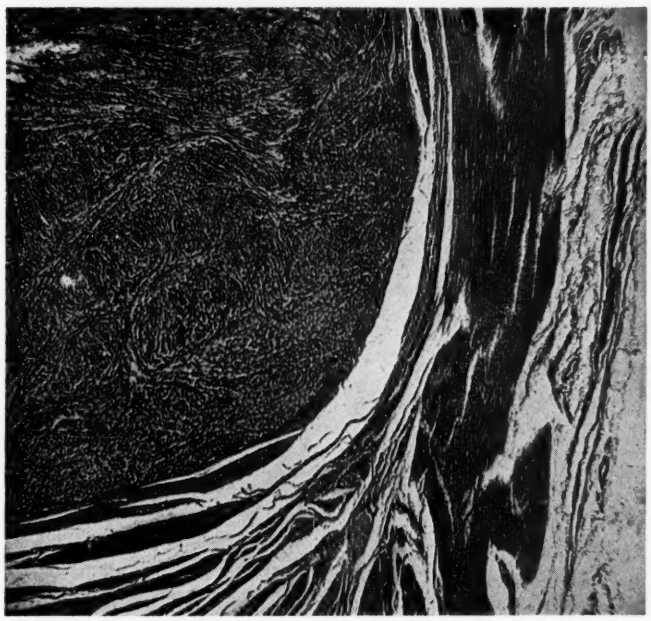


FIG. 211.—The junction between the tumour and the circular muscle. Some of the muscle fibres can be seen merging into the growth. (*Low power.*)

directions, with a minimum of connective stroma. Blood-vessels were extremely scanty and had very thin walls. The muscle fibres were similar to those of ordinary unstriped muscle, but were distinctly longer and thicker. The nuclei were uniform in size and shape, but were plumper than the normal round-ended rod-shaped nuclei of plain muscle, and apart from this increase in size of the nucleus and cytoplasm they were indistinguishable from those of the adjoining circular muscle fibres. The cellularity of the tumour appeared rather less, however, because of this increase in thickness of the individual fibres. No large areas of degeneration or cellular infiltration were present, but many of the tumour fibres showed a peculiar nodal swelling of the cytoplasm. About half the length of the cell was swollen to twice the usual diameter, and this stained more deeply with eosin. Cells showing this change were present but scantily in the section, but they tended to appear in adjacent fibres, producing a palisade appearance. The remainder of the cytoplasm of the affected muscle fibres seemed proportionately thinner, giving the impression that part of the swelling was due to a focal condensation of the cytoplasm. The change would appear to be a degenerative one, as the nuclei of the affected fibres were swollen and stained more deeply. Similar but less marked

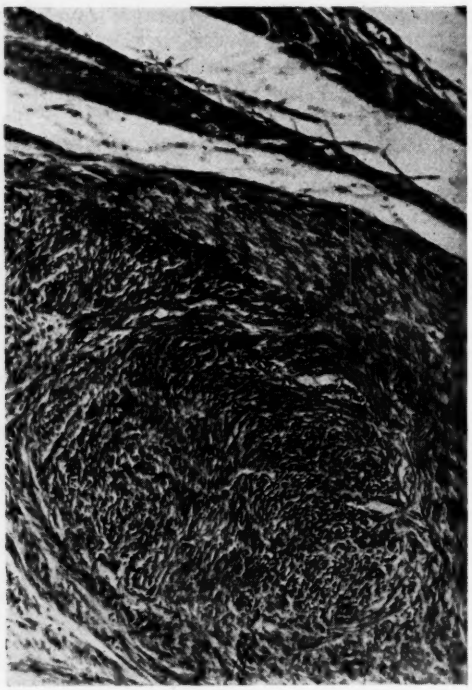


FIG. 212.—The margin of the tumour. Here it is clearly demarcated from the circular muscle. (*Medium power.*)

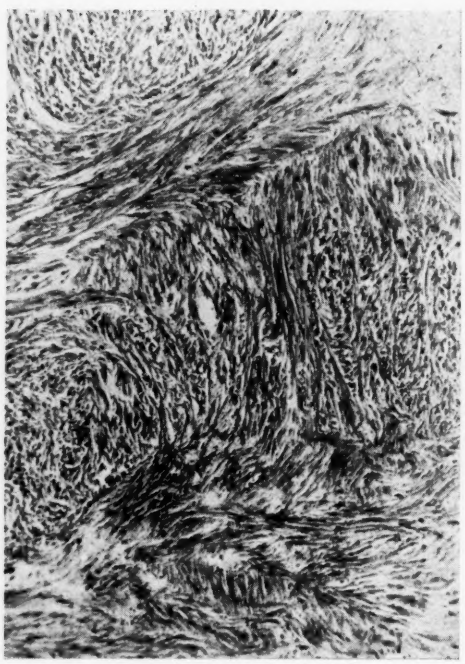


FIG. 213.—The centre of the tumour. Showing the typical whorled structure of the myoma, with bundles of smooth muscle running in different directions. (*Medium power.*)

FIG. 214.—Showing the peculiar oval swellings of the cytoplasm of some of the muscle fibres. (*High power.*)

changes were found occasionally in the neighbouring circular muscle coat. The demarcation of the tumours from the circular muscle was generally good; over the greater part of their circumference a thin line of collagenous fibres was to be found, but at several points this could not be recognized, as the outermost fibres of the tumours—which mainly ran circularly—appeared to mingle and fuse with those similarly arranged fibres of the circular muscle.

Microscopic examination of a transverse section of the lower end of the œsophagus showed the epithelium of this section, which was taken about 4 cm. from the cardiac orifice, of the usual squamous, non-keratinizing type; it appeared to be slightly thicker than usual, but presented no pathological features of note. The lamina propria was seen to be of normal thickness, and consisted of rather dense irregularly arranged bundles of collagen which were rather coarse. The capillary blood- vessels were numerous, and some showed a perivascular round-celled infiltration. The muscularis mucosæ was definitely increased in thickness, but otherwise showed no special changes. In the slightly thickened submucosa the collagen fibres were more loosely arranged, and no signs of inflammation were seen. The circular muscle was from three to four times the normal thickness, and both the number and width of the muscle bundles were increased. Some of the fibres showed the bullous hyaline swellings which were noted in the tumours as giving the appearance of a nodal arrangement of the cytoplasm with pale staining areas between them. In longitudinal section similar palisading was noted. Auerbach's plexus was noted to be much more prominent than usual. The longitudinal muscle was hypertrophied, about two-thirds the thickness of the circular muscle, and showed the same nodal degenerative features. The outer fibrous tissue coat exhibited no special pathological change.

SUMMARY OF REPORTED CASES

Table I.—Reported Cases of Myoma of the Œsophagus

Author and Date	Sex and Age	Number	Size and Site	Symptoms	Remarks
Monro 1797	—	2	—	—	Constricted the œsophagus
Charles Bell 1816	—	2	(*a*) At level of cricoid (*b*) Middle of œsophagus	—	—
Lippich 1838	—	1	2 × ½ in., 4 in. proximal to the cardia	—	Ulcerated into trachea at level of bifurcation
Virchow 1863	—	1	12 mm., in lower third	—	Arose from muscularis mucosæ
Eberth 1868	F. 50	1	9·1 × 11·9 × 3·5 cm., in posterior wall, embracing lower third	—	Horseshoe-shaped and embraced œsophagus
Coats 1872	M. 61	1	2 × 4¾ × 1¼ in., posterior surface 7 in. from glottis	Dysphagia	Direct cause of death. Pedunculated
Rolleston 1875	F. 49	1	Cherry-sized, junction of upper and middle thirds	—	Originated in circular muscle
Tonoli 1880	M. 70	1	Hazel-nut-sized, middle third	Dysphagia and vomiting	Pedunculated and caused obstruction to food, and œsophageal dilatation present above the tumour
Trastour 1881	M. 56	1	Small egg, inferior part	—	Calcified, and compressed descending aorta

[*Continued on next page*

Table I.—REPORTED CASES OF MYOMA OF THE ŒSOPHAGUS—*continued*

AUTHOR AND DATE	SEX AND AGE	NUMBER	SIZE AND SITE	SYMPTOMS	REMARKS
J. Meyer 1882	F. 78	1	8 cm., posterior wall of upper third	—	Dilatation and hypertrophy of œsophagus above the tumour. Displacement of mediastinal structures
Reher 1885	F. 43	1	Hazel-nut-sized, inferior part	—	Pedunculated
Phillip Meyer 1887	—	1	2 × 7 cm., anterior wall 3 cm. below tracheal bifurcation	—	—
Illig 1894	—	1	5 × 5 × 2 cm., posterior wall at level of bifurcation of trachea	—	Calcified, originated from internal muscle layer
Pichler 1897	M. 50	14	Two in middle part, rest about cardia	—	Connected with the circular muscle
Fagge 1899	M. 38	1	2 × 1¼ × 1 in., middle third	—	Originated in longitudinal muscle
Maucher 1900 (1)	—	1	3 × 1·5 × 2 cm., just below tracheal bifurcation	—	—
(2)	—	1	2 × 5 cm., anterior wall		
Kraus 1902	—	1	—	—	—
Bryant 1905 (1)	M. 60	1	Chestnut-sized, cardia	—	Originated in outer coat
(2)	F. 62	2	(*a*) 3·2 × 3 × 2·5 cm., 14 cm. below pharynx	—	Narrowed lumen of œsophagus
			(*b*) 1·4 × 0·7 × 0·5 cm., at cardiac end	—	Opposite to this was an ulcer
Orth 1909	M. 27	1	Surrounded cardia	—	Ring-like structure
Frank 1911 (1)	M. 46	1	Plum-sized, anterior wall at level of bifurcation	—	Bi-lobed, mucosa covering it was exfoliated, exhibited perivascular round-celled infiltration
(2)	M. 60	2	(*a*) Cherry-sized, just above bifurcation, anterior wall	—	Circumscribed areas of calcification
			(*b*) Little smaller and at bifurcation	—	—
Anitschkow 1911 (1)	—	1	Hazel-nut-sized, cardiac end	—	Submucous site
(2)	—	1	Hen's-egg-sized, anteriorly and laterally about cardia	—	Originated in outer muscle layer
(3)	—	1	Bean-sized, laterally at level of tracheal bifurcation	Symptoms of stenosis	Diagnosed as a carcinoma

Table I.—Reported Cases of Myoma of the Œsophagus—*continued*

Author and Date	Sex and Age	Number	Size and Site	Symptoms	Remarks
Gajet 1911	F. 75	1	Almond-sized, above cardia	Dysphagia	Pedunculated, directly responsible for death
Milanovic (1) 1914	F. 76	1	Nut-sized, anterior wall at level of tracheal bifurcation	—	Calcified, projected into lumen
(2)	M. 25	1	10 × 6 cm., anterior wall 4 cm. from cardia	—	Associated with a diverticulum of œsophagus
(3)	M. 68	2	(*a*) Hazel-nut-sized, right posterior wall 3·5 cm. from cardia	—	—
			(*b*) 6 × 5 cm., just above, in posterior wall	—	Associated with a diverticulum
(4)	M. 63	1	Hazel-nut-sized, at cardia	—	Associated with a gastric myoma
(5)	M. 42	1	Hen's-egg-sized, anterior wall at level of tracheal bifurcation	—	Lobulated by a fissure
Hall 1916	F. 17	1	Diffuse through nearly whole œsophagus	Dysphagia	Probably a sarcoma
Bauer (1) 1917	M. 41	1	Plum-sized, posterior wall of upper third	—	Projected into lumen, vascular and œdematous
(2)	M. 38	1	Pea-sized, posterior wall	—	—
Tschlenow (1) 1922	F. 20	Multiple nodules	23 × 9 cm., 3 cm. from cricoid	—	Associated with gastric myoma
(2)	M. 25	2	(*a*) 1·5 × 1 × 1 cm. (*b*) 2·5 × 2·5 × 1 cm. Both (*a*) and (*b*) at level of tracheal bifurcation	—	Tumours united by a bridge of tumour tissue
(3)	F. 71	1	4 cm. in diameter, just above cardia, with a tail 3 × 1 × 1·5 cm. around cardia	—	Arising from circular muscle, and tends to surround the œsophagus
(4)	F. 62	1	1 × 0·5 mm. at tracheal bifurcation	—	—
Stewart (1) 1931	F. 32	1	3·5 × 1·5 × 1·3 cm., 2·5 cm. above cardia	—	Associated with a diverticulum from circular muscle, some local hypertrophy
(2)	F. 59	1	1·5 × 1 × 1·5 cm., 1·2 cm. above cardia	—	Associated with a diverticulum and from circular muscle
Spitznagel (1) 1931	F. 64	1	6 cm. long, in lower part	—	Calcified tumour
(2)	M. 68	1	Child's-fist-sized with a peduncle, 7 × 8 × 5 cm. and pedicle 2·5 cm.	Dysphagia	Long pedicle, diagnosed substernal goitre
Bezza (1) 1932	M. 68	1	Hazel-nut-sized, 6 cm. from cardia	—	Arising from circular muscle

[Continued on next page

Table I.—REPORTED CASES OF MYOMA OF THE ŒSOPHAGUS—*continued*

AUTHOR AND DATE	SEX AND AGE	NUMBER	SIZE AND SITE	SYMPTOMS	REMARKS
Bezza (2) 1932	M. 63	2	(*a*) Cherry-sized, at tracheal bifurcation, posterior wall	—	Projected into lumen
			(*b*) Slightly larger, 3 cm. from cardia	—	Arose independent of muscle coat
(3)	M. 73	1	Pea-sized, in posterior wall a little above cardia	—	Slight muscular hypertrophy above and below. Arose from longitudinal muscle
(4)	M. 35	1	Rice-grain-sized, in posterior wall in upper third	—	Arising from muscularis mucosæ
(5)	F. 60	1	8·5 × 5 cm., at level of arch of aorta	—	Deviation of lumen of œsophagus
In Museum at Cairo (G. G. Turner)	M. 60	1	Cherry-sized, lower end	—	—

DISCUSSION

A thorough search of the literature has produced 49 cases only of myomata of the œsophagus, the more important features of which are tabulated. In 12 the age was not given, but from the remainder it is evident that the tumours are found more commonly in the aged, 13 of these being between 60 and 70 years. It should be noted, however, that this decade has the highest death-rate from all causes, and as the tumours are as a rule benign and do not cause death, it is to be expected that the incidence would be greatest in this age period.

Table II.—AGE INCIDENCE.

AGE IN YEARS*	NUMBER
10–20	1
20–30	4
30–40	4
40–50	5
50–60	4
60–70	13
70–80	6
	37

* 12 not recorded.

These tumours have been found with greater frequency in the male (22) than in the female (15); in this they resemble the other myomata of the intestinal tract. It has been asserted (Bezza) that this may be due to the greater liability of the male tract to irritation from alcohol and coarse food. But it is very doubtful if there is a real sexual difference in the incidence. All the reported tumours were

found at post-mortem examinations, and in most hospitals the autopsies on males are more frequent than on females. The proportion over the last ten years at the Royal Victoria Infirmary, Newcastle-upon-Tyne, is 1·6 to 1. Bezza, in 1932, based his analysis on 26 cases, and found a distinct preponderance of males over females, 3 to 1, but the addition of cases which he omitted and those reported since that date shows a more equable distribution.

The tumours occurred singly in 35 cases and were multiple in 11.

Unlike carcinoma of the œsophagus, the tumours may occur at any part of the œsophagus, but the distal third is more frequently affected. In this series 8 were in the upper third, 18 in the middle, and 28 in the lower third. The posterior wall is a more common site than the anterior, and the left and right lateral walls are the least likely to be affected.

The size of these myomata may vary from a millet seed (Bauer's second case) to a diffuse mass several inches long (Tschlenow's first case, A. J. Hall's case). The largest tumours may become pedunculated, and not unnaturally these are the most likely to give rise to symptoms (4 out of 5). The larger non-pedunculated tumours show a tendency to encircle the wall of the œsophagus (Anitschkow's second and third cases, Pichler's case, and Bezza's fifth case).

Symptoms referable to the œsophagus were found in 6 cases only, and 4 of these were pedunculated; the other 2 were both of considerable size and showed a tendency to encircle the œsophagus (Anitschkow's third case and Hall's case), but there was some doubt as to the benignity of the tumour reported by A. J. Hall. In Bryant's second case, there were symptoms referable to the gastro-intestinal tract, but a state of senile dementia existed and actual dysphagia was not reported: such symptoms as were observed might have been due to the chronic gastric ulcer which was found at autopsy. In this analysis, out of 49 œsophageal myomata only 3 were believed to have been the cause of such a degree of dysphagia that asthenia and death resulted, and 2 of these were pedunculated.

The precise origin of the tumour was noted in 14 cases, 8 being from the longitudinal muscle coat, 4 from the circular muscle, and 2 from the muscularis mucosæ. In the other cases the site of origin was not recorded, but 7 were said to be covered by the mucous membrane and 1 by the longitudinal muscle.

Generally speaking, the tumours tended to project slightly into the lumen of the œsophagus.

The smaller growths have a smooth surface and are freely movable; the larger tend to be more nodular. The consistency is firm, and the section shows the greyish-white watered-silk appearance typical of myomata elsewhere. They are usually comparatively avascular, and show up well against the surrounding brownish muscle, but a few are better supplied with blood-vessels and have a pink colour. The tumours are well circumscribed, but a connective-tissue capsule thick enough to be visible to the naked eye is rare. Anitschkow states that only the larger tumours are encapsulated. This is refuted by Tschlenow, who cites his own cases in proof and further denies that the age of the tumour can be made out from its macroscopical appearance or histological structure.

Several cases had associated changes in the œsophagus. J. D. Stewart reports in a recent article 2 cases of myomata with diverticula, and areas of mucous membrane resembling gastric mucosa. He believes that the diverticulum is due

to the force of swallowing acting on the tumour, causing it to rotate and enlarge eccentrically, and to a thrusting out of the mucosa. Other factors may be a thinning of the wall in the region of the tumour and a congenital defect in the wall. One would imagine that the presence of the myomata in the wall of a muscular tube would lead to some interference with the muscle, but both hypertrophy and dilation are very rare, and were found in only 3 instances. Joseph Meyer reported both dilation and hypertrophy above a large tumour (8 cm. long) which had displaced the common carotid and subclavian arteries to the left, the trachea and innominate artery to the right, and was compressing the left recurrent laryngeal nerve. It may safely be presumed that such a tumour had caused some obstruction, and as no history of dysphagia was recorded, it is probable that the degree of hypertrophy had been sufficient to outcome it. Bezza noted a slight muscular hypertrophy above and below the small pea-sized tumour in his third case, although no obstruction could be demonstrated. In that recorded by Tonoli, a pedunculated hazel-nut-sized myoma was found with a bullous dilatation above it in the upper half of the œsophagus. It was associated with symptoms of dysphagia and vomiting, but no hypertrophy was reported.

Microscopical Examination.—The characteristic microscopical picture is that of myomata elsewhere, bundles of smooth muscle fibres running in all directions; these neoplastic fibres are indistinguishable from those in the muscular coats except for a slight increase in size and their irregular arrangement. The nuclei are rod-shaped, but in transverse or oblique sections appear rounded or oval. The connective-tissue content of these tumours varies considerably in amount. Some, particularly the larger and well-encapsulated ones, show much collagen, and this may even be arranged as fibrous trabeculæ in the nodular type, but in the pedunculated tumours elastic tissue is frequently noted. Anitschkow, in his article, describes a fine collagenous network between each individual fibre, and Bezza reports a fine reticulum in his cases. In the great majority there is a comparative avascularity, and Bezza points out that many of these have both thin-walled vessels and vascular lacunæ lined with endothelium.

Genesis.—Various theories have been advanced as to the origin of these tumours, but it cannot be said that they are very impressive. Tschlenow regards them as being in all probability congenital; while Anitschkow favours the theory of local muscular hypertrophy. Bezza combines these views, and divides the myomata into two groups: (*a*) Those arising independently of the muscular coats; (*b*) Those which arise in a muscular coat. The first of these appears to be due to some congenital defect, a misplaced myogenic cell or cells, which in later life proliferated to form the growth; while the latter is ascribed to an over-growth of existing muscle. Bauer noted numerous capillaries at the edge of the tumour, often with a perivascular leucocytic infiltration, and formulated the extraordinary theory that these leucocytes could gradually change into connective tissue and muscle cells, and quoted Kleinwachter as his authority. The absence of leucocytic infiltration in the centre of the tumour was due to the fact that they had already changed into the muscle cells. Scalone, not to be outdone, thought these tumours arose from eosinophils, and believed he had seen transition forms between an eosinophil and a smooth muscle cell! But the etiology of myomata of the œsophagus is as uncertain as that of myomata elsewhere.

Discussion of the Case Reported.—The case reported here is a straightforward one except for the unusual distribution of the hypertrophy. The tumours were small, pea-sized, and situated at the junction of the upper and middle thirds of the œsophagus. They bulged forwards and encroached on the lumen to a considerable extent, reducing its circumference to 2·7 cm. (normal being about 4 cm.). That this had caused some obstruction cannot be denied: there was dilatation and hypertrophy above them, and the firm inelastic nature of the tumours, by limiting the normal distensibility of the organ, was no doubt a contributory factor in the obstruction. But it is difficult to understand why there should be present a gradually increasing muscular hypertrophy and narrowing of the lumen from the site of the tumours to the cardiac orifice. These considerably exceed the changes at the level of the growths and above it: the lumen reaching a minimum circumference of 1·8 cm. just above the cardiac orifice. The degree of hypertrophy below the tumours was proportional to the narrower lumen, and the circular muscular coat at the lower level measured 0·7 cm., compared with a normal of about 0·1 cm. and the 0·2 cm. found immediately above the level of the growth. This has been recorded once before. In other parts of the intestinal tract the hypertrophy associated with narrowing of the lumen is proportional to its duration and extent, and the distal part of the tube, far from showing the hypertrophy so marked in this case, is either of normal thickness or may even show muscular atrophy if the blockage is severe. The only exceptions to this general statement are the case now described, and Bezza's third, which showed slight hypertrophy above and below a small tumour. Bezza offers no explanation of this unusual finding; he merely mentions it in describing the œsophagus. The hypertrophy below may have been a coincidental lesion not directly related to the tumours above it, but the usual causes of hypertrophy are here absent. We can eliminate obstruction from without, and cicatrical stenosis from chronic peptic ulcer or swallowed caustics or acid. Hypertrophy of the lower end of the œsophagus is most commonly associated with dilatation, as in achalasia of the cardia. In this case, no dilatation was present in the lower half, and achalasia, compensated or otherwise, can probably be excluded. The suspicion that this hypertrophy is directly related to the tumours above it is supported by the absence of any other etiological agent.

It is possible that these tumours in the middle of the œsophagus directly affected its nervous mechanism, as they lay in close proximity to Auerbach's plexus, and they may well have caused irritation and irregular muscular contractions. It is also possible that, replacing, as they did, a large part of the circular muscle coat, muscular conduction was impeded and blocked, and the distal hypertrophy was the result of irregular and uncontrolled contractions. On the other hand, in squamous carcinoma of the œsophagus, where the possibilities of local muscular and nervous interference are much greater, one does not get hypertrophy below the obstruction.

In conclusion, one may mention yet another possibility—idiopathic hypertrophy of the œsophagus. In view of the advance of diagnostic methods, it is now a very rare lesion, but cases confirmed by post-mortem study are described (Wood). It may be that here we have multiple congenital abnormalities, as a congenital origin has been suggested for both myomata of the œsophagus and the so-called idiopathic hypertrophy.

SUMMARY

A case of multiple myomata of the œsophagus which resulted in fatal stenosis is described, and the literature is briefly reviewed.

I wish to express my sincere thanks to Dr. J. Greig Thomson for his stimulating assistance, to Miss E. A. Richardson for translating the Italian, and to Professor G. Grey Turner for his suggestions and criticism.

BIBLIOGRAPHY

ANITSCHKOW, *Virchow's Arch. f. path. Anat.*, 1911, ccv, 443.
BAUER, *Ibid.*, 1917, ccxxiii, 34.
BEZZA, *Pathologica*, xxiv, 71.
BRYANT, *Jour. Amer. Med. Assoc.*, 1905, xlv, 2008.
COATS, *Glasgow Med. Jour.*, 1872, N.S. iv, 201.
EBERTH, *Virchow's Arch. f. path. Anat.*, 1868, xliii, 137.
FAGGE, *Trans. Pathol. Soc. Lond.*, xxvi, 94.
GAJET, *Soc. des Sci. méd.*, 1910, Nov. 9.
HALL, *Quart. Jour. Med.*, ix, 409.
ROLLESTON, *Trans. Pathol. Soc. Lond.*, l, 73.
SPITZNAGEL, *Radiology*, 1931, xvii, No. 3, 570.
STEWART, *Arch. of Pathol.*, xii, 77.
TRASTOUR, *Bull. Soc. anat. de Nantes*, 1881, 7.
TSCHLENOW, *Virchow's Arch. f. path. Anat.*, 1923, ccxlii, 239.
WOOD, *Arch. of Pathol.*, xiv, 767.

The Following Papers were Read in Abstract only :—

FRANK, *Inaug. Dis.*, München, 1911.
ILLIG, *Inaug. Dis.*, Giessen, 1894.
MAUCHER, *Inaug. Dis.*, Zürich, 1900.
MEYER, P., *Inaug. Dis.*, Freiburg, 1887.
MEYER, J., *Inaug. Dis.*, München, 1882.
REHER, *Inaug. Dis.*, Kiel, 1885.
PICHLER, *Prag. med. Woch.*, 1897, xxii, 445.

TRAUMATIC RUPTURE OF THE URETHRA

EIGHT PERSONAL CASES, WITH A REVIEW OF 381 RECORDED RUPTURES

(CHILDBIRTH AND WAR INJURIES EXCLUDED)

By A. SIMPSON-SMITH

SURGEON, HOSPITAL FOR SICK CHILDREN, GREAT ORMOND STREET, LONDON
SURGEON TO OUT-PATIENTS, WEST LONDON HOSPITAL

TRAUMATIC rupture of the urethra is an uncommon injury. Some figures show that only 4 cases per 1400 in-patient admissions are to be expected in any one year; yet even this may be a too generous proportion, for many surgeons pass through a full professional life without meeting more than a single example. Familiarity with their management, however, is desirable, for hesitant or defective treatment may plunge a healthy life into one of strangury, stricture, sinuses, stone, perineal abscesses, or other miseries of urinary disease.

Refreshment is sometimes gained by recounting individual experiences. Eight personal cases are submitted, each possessing some separate point for discussion or improvement. In addition, all the available writings of the past twenty years, yielding some 381 cases, have been surveyed in order to present a reliable picture and to measure the trend of modern urological views.

Details of the eight cases will first be given, but comment on their treatment will be reserved for the general discussion. An analysis of the total cases will contrast 'bulbar' and 'membranous' injuries, and show how often the perineum has been incised, the torn ends sutured, in-dwelling catheters or suprapubic drains used, and the number of subsequent strictures recorded. The discussion will indicate the debatable points for support or condemnation, and will suggest the safest method of negotiating the emergency.

AUTHOR'S CASE REPORTS

Case 1.—R. M., aged 70 (July 27, 1933), fell while standing on a box with legs astride the edge. Immediate sharp perineal pain, and fainting.

On admission half-an-hour after the accident there was extensive bruising of perineum and groins; local tenderness under pubic arch; blood dripping from the urethra; intense desire but inability to pass water. Warned not to micturate.

Immediate suprapubic cystostomy. A retrograde gum-elastic catheter was passed down to the rupture in the bulb, and after gentle rotation its eye emerged at the penile meatus. A soft rubber catheter was tied to the bladder-end of the gum-elastic and by pulling on the penile end the rubber catheter was piloted down the urethra until only the tip rested inside the trigone. This rubber tube now became an indwelling catheter. A large suprapubic drain was then inserted and connected to a Sprengel's pump.

The in-dweller was left out for twenty-four hours on the 28th day, when the patient passed small amounts of urine through the penis, and through the healing suprapubic wound. The latter finally closed on the 35th day.

Urethroscopy seven weeks after the accident, with the added advantage of Mr. V. E. Lloyd's expert eye, showed a small ledge of scar tissue on the floor of the bulb, but no sign of a stricture. A 26 F. passed easily. Unfortunately three days after this examination a small indurated swelling 4 in. by 2 in. appeared along the closed suprapubic scar. Catheterization

produced a foul blood-stained urine and much gas. The cystostomy was re-opened and bladder wash-outs were maintained for five days. The wound re-healed on the 20th day. The patient was finally discharged exactly three months after the accident, " passing water freely ".

EXAMINATION 2½ YEARS AFTER THE INJURY.—Health excellent; no catheterization since discharge from hospital; no pain or difficulty in micturition other than occasional dribbling and frequency—attributable to an enlarged prostate obvious on rectal examination. There is no palpable evidence of urethral scar and the stream is good and strong. The patient is emphatic that the penis has atrophied since the operation and when questioned about erection maintains that " before the injury it used to fly out at any time, but now it is only proud when the bladder is full, and then not very strong ". His age, however, must be taken into consideration. Urethrogram shows a slight deformity at the site of injury but no stricture. The membranous urethra is elongated and irregular. (*See Fig.* 216.)

Case 2.—A. B., aged 25 (Aug. 25, 1933), was standing with one leg on a table and the other on a step-ladder when the latter slipped away. One limb shot horizontally along the table, the other vertically downwards, allowing the perineum to fall heavily on the edge. The patient lay in great pain for twenty minutes, but then walked alone to hospital.

On admission half-an-hour after the accident there was intense perineal pain and a tender lump on the right side of the bulbous urethra, but no ecchymosis. Clear urine was unfortunately voided in the surgery for testing, but later when wishing to pass water the patient only bled from the meatus.

Immediate operation. A catheter was passed and, although there was a slight hitch in the bulb, the instrument slid comfortably into the bladder, indicating only a partial rupture. The bladder was opened to divert the stream. A new catheter with several lateral holes was passed up the penis to act as an in-dweller, and, with a finger down the suprapubic incision, the tip was made to lie just below the internal sphincter to avoid any trickling of urine along the catheter to the traumatized area. A Sprengel's pump was attached to the cystostomy drain.

The urethra was irrigated daily and lightly through the multiple holes of the in-dwelling catheter. On the 11th day there was slight difficulty in changing the catheter, and pus suddenly poured from the urethra. Culture yielded *Streptococcus* and *Proteus*, but no *B. coli* or *gonococcus*. Wassermann and Kahn tests were negative. On the 15th day the catheter lay out on the bed all night, and as it could not be returned the suprapubic incision was re-opened by a locum. A descending catheter readily appeared at the meatus, and a soft rubber catheter was left in the urethra. The patient lost ground, the temperature remained at 103°, and a painful, soft, fluctuant, and very tender perineo-scrotal swelling appeared. A mid-line incision produced thick reddish pus, and the temperature became normal two days later.

Eight weeks after admission the catheter was out for one hour, and on the next four days for two, four, twelve, and twenty-four hours. The patient left hospital nine weeks after the injury, passing water quite well. A urethrogram looked normal, but on passing a sound there was a definite soft stricture which yielded to kindly dilatation. This was repeated once a month until the eighteenth month.

EXAMINATION 2½ YEARS AFTER THE INJURY.—The patient looks remarkably well, but although he never has to get up at night he cannot hold his water for longer than one hour by day. There is a small hard lump with a tiny depression proximal to it in the perineum. The stream is good and thick, with plenty of force; the urine is normal. At first the penis bent down on erection, but soon straightened out. Coitus still produces intense perineal pain which lasts until the following noon, and is only indulged in from time to time. Urethrogram now shows a good wide channel with some irregularity, but no stricture, in the bulb. (*See Fig.* 216.)

Case 3.—J. K., aged 5 (April 15, 1932), was knocked down by a car, the wheel passing over the pelvis.

On admission half-an-hour later the boy was very shocked and in great pain. The lower abdomen was intensely bruised, swollen, rigid, and very tender. There was a large gap between the two halves of the symphysis pubis. Blood oozed from the meatus, but there was no perineal hæmatoma. In spite of the critical condition of the child, delay seemed fraught with the risks of extravasation, of severe intestinal injury, and the onset of secondary shock.

An immediate subumbilical incision exposed large blood-clots in the abdominal wall. The peritoneal cavity was deliberately opened, and as a rapid examination of the abdominal viscera showed no injury, the cavity was closed. A distended bladder was noted riding up towards the umbilicus, attached by two lateral folds of peritoneum containing the vesical vessels, almost like a toy balloon tethered by two convergent strings. There was an ominous gap of at least three inches between the right and left parts of the symphysis, and through the gap the apex of a miniature prostate could readily be palpated. The bladder was emptied by puncture with a large-bore needle attached to a sucker to avoid soiling, and opened. A soft rubber catheter was retrograded to the rent in the membranous urethra, the eye seized by forceps, and easily pulled up through the gap. The tip of an ascending catheter from the penis was similarly seized and elevated (*Fig.* 215). The tubes were joined, and by pulling on the meatal guide the descending catheter was drawn along the urethra to appear at the glans. This in-dweller traversed a gap of two inches between the torn urethral ends. Light digital pressure on the trigone easily pushed the bladder downwards and forwards to approximate these torn ends, but the viscus rose again on removing the finger. One regretted that something could not be devised to hold the bladder down. It was clear that a suture could readily be inserted into the accessible prostatic end, but the penile end was so deeply situated, and surrounded by such traumatized tissue, that it was doubtful whether the suture could be passed into it, or secured sufficiently to keep the torn ends together. Insertion of the suture would take time even with the advantage of the enormous symphyseal gap, and was abandoned as the child was too ill for much manipulation. A perineal section was also out of the question—it could be attempted later if necessary. Accordingly the abdominal incision was hurriedly closed, leaving a bladder drain for later attachment to a Sprengel, and a long strip of corrugated rubber to drain both the cave of Retzius and the vast traumatic cavern below it. After a blood transfusion the boy was returned to bed.

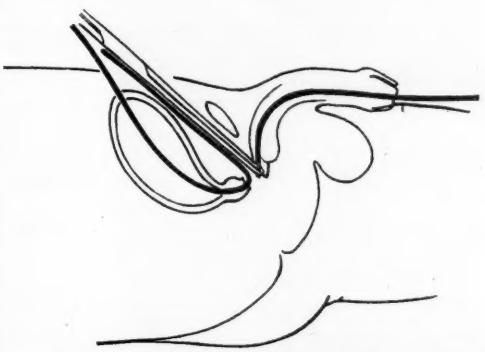


FIG. 215.—*Case* 3. Showing the catheters being pulled up through the gap between the two halves of the fractured symphysis pubis. The tips were united and the bladder catheter pulled down along the urethra to act as an in-dweller. By this simple means a perineal incision was avoided.

The next few days were made pleasant by his splendid recovery. He was as yet too weak and his pelvis too shattered for the adoption of the Fowler position. Obviously sitting him bolt upright would encourage the abdominal viscera to force down the bladder; on the other hand, high blocking of the bottom of the bed would ensure all urine falling into the fundus from the ureteric orifices, and thus prevent any trickling along the resident catheter into the traumatized area. A continuous warm saline irrigation up through the catheter and out through the suction tube was an attempt at compromise—in the hope that any leak of urine would be so dilute as to rob it of any of the toxic effects familiar in extravasation. Unfortunately, on the 12th day pus oozed from the Retzius drain, but in spite of this the suprapubic tubes were removed on the 21st day. Owing to the gross separation of the torn urethral ends, the in-dwelling instrument was left in until the sixth week.

The boy now passed urine from the penis, and through the small purulent suprapubic fistula. Removal of a sequestrum at the eighth week terminated a short-lived osteomyelitis, and the extraction of two small bladder stones through the dilated fistula cleared up any pus from that source. At the second lithotomy the fistulous track was found adherent to the back of the pubis, so it was dissected off the bone. The fistula, which had remained open for nearly six months, closed in a week!

The tenth month saw the patient discharged. His wound was soundly healed, micturition was free, uroselectan showed no abnormality of the urinary tract, and urethrography demonstrated good canalization of the whole urethra. Yet he disliked the passing of a No. 6 catheter—a feat only possible in the hands of Sister Dobson, to whom great tribute is due for so completely winning the confidence of the child and his urethra throughout the hospital catheterizations.

Urethroscopy at the eighteenth month, again with Mr. V. E. Lloyd, showed a well-defined circular stricture in the membranous portion, but a No. 6 English—the largest his penis would allow—slipped into the bladder without difficulty.

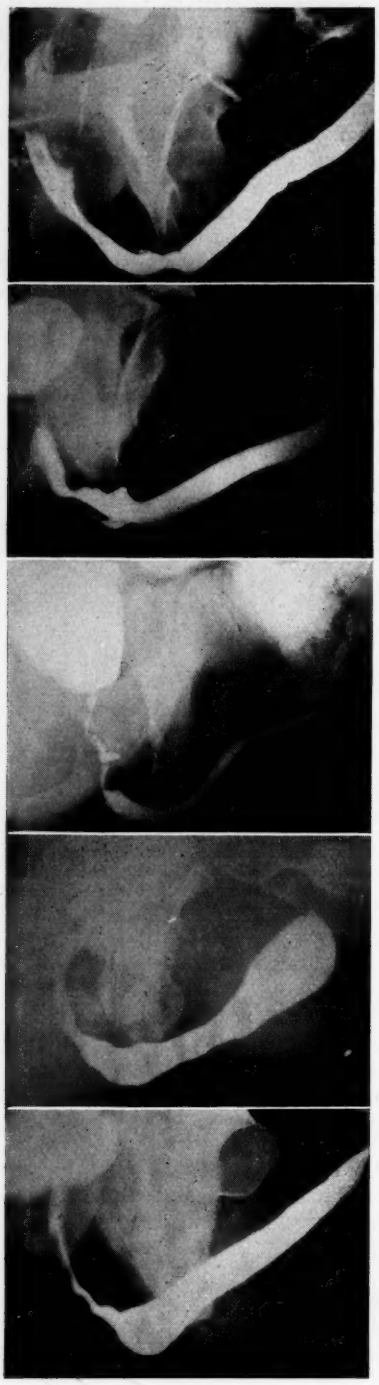


FIG. 216.—Urethrograms of *Cases* 1, 2, 3, 4, and 5 (from above downwards).

EXAMINATION 4 YEARS AFTER THE INJURY.—The patient is perfectly well; there is no pain or difficulty with micturition; the stream is good and strong; the urine clear. There appears to be no atrophy of the penis. Uroselectan normal. Urethrogram as shown in *Fig.* 216.

Case 4.—D. C., aged 47 (Aug. 29, 1934), was loading logs from a ship to a barge. One trunk swung over on a crane and hit the patient on his pubis and penis, knocking him from the vessel into the bottom of the barge. He experienced great pain at the tip of his glans, and to a lesser extent in his pelvis. He could not rise, and was brought to hospital twenty minutes after the accident.

On admission he was in extreme shock and bleeding freely from the penis. There was intense pain in the lower abdomen, which was rigid, and in both legs. A large hæmatoma of the perineum rapidly developed and extended to the scrotum. X rays showed fracture of both sides of the pubis and a fracture-dislocation of the right sacro-iliac joint. A catheter was passed in the surgery and although buried to the hilt merely drew off blood. On running in a measured amount of fluid a very little returned. The patient was admitted to the wards, intravenous therapy commenced, and an immediate operation performed.

A subumbilical incision exposed much blood-clot and a distended bladder riding out of his pelvis, rather higher than normal. The extreme dislocation seen in *Case* 3 was not present. A fragment of bone projected into the bladder wall and was causing much hæmorrhage from the vesical venous plexus. The bleeding points were controlled, and the incised viscus was found to contain blood. The cave of Retzius opened into a vast cavern at the apex of the prostate; blood welled out of this chasm, but could not be traced to any particular bleeding points. Catheters were rapidly retrograded and 'antegraded' to the rent in the membranous urethra, their tips were seized, brought up through the wound, united, and the upper one pulled down along the urethra by traction from the penile one. A finger exploring the ruptured site found a long gap between the torn ends traversed by the catheter. Digital pressure on the trigone easily approximated these torn ends, but, as in *Case* 3, the viscus rose again on removing the finger. A piece of thick rubber sheeting was cut into a florin-sized circle with a hole in the middle to admit the shaft of a stout De Pezzer catheter. This improvised 'extension-catheter' was attached to the already resident sound, and 'railroaded' down the urethra until the head and collar rested upon the trigone (*Fig.* 217). Light digital traction on the penile end of this new in-dwelling catheter readily held the bladder down and obliterated the gap between the torn ends. The whole procedure

occupied only a few minutes. A large-sized suprapubic tube was placed in the bladder, and the patient returned to bed. A Sprengel was attached to the suprapubic tube, and a 1-lb. weight to the penile catheter by means of a pulley over the end of the bed. One felt that such a pressure was considerably less than that of the various forms of hydrostatic bags, especially those fitted with strong springs clamping the inside of the bladder to the perineum.

A visit to the ward late that night revealed a patient who affirmed that his penis and perineum were remarkably comfortable. His condition was excellent. The pound pressure was maintained for twelve days, and throughout this time there were repeated stout denials of any discomfort. On the 4th and 12th days, at the changing and removal of the collared De Pezzer, a cystoscopic light placed down the suprapubic tube-shaft showed a trigone bearing no marks of the slightest pressure necrosis.

[The author's tenure of office at the Hospital now terminated, and thanks are due to the authorities for further details.]

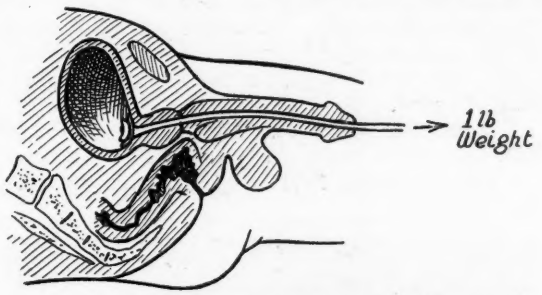


FIG. 217.—*Case* 4. Showing the de Pezzer catheter with its circular rubber collar in position, after it had been pulled down the urethra by means of the manœuvre employed in *Case* 3 (*see Fig.* 215). A 1-lb. weight attached to the catheter pulled the trigone downwards to approximate the torn ends. A perineal exploration and end-to-end suture could not have been performed as the man was too ill, and this improvised method was found to work well. The patient always maintained that he was comfortable, and 'cystoscopy' down the suprapubic tube-shaft on the 4th and 12th day showed no trace of pressure necrosis. It was felt that the 1-lb. weight was considerably less than that of various forms of hydrostatic bags or strong springs used to press the prostatic bed against the perineum.

Slight urinary sepsis yielded to bladder wash-outs. On the 28th post-operative day sudden profuse bleeding per rectum occurred, and was repeated next day. Blood transfusions were given. A radiograph showed the right sacro-iliac joint displaced. On the 50th day a fistula suddenly appeared on the under surface of the penis just behind the glans, and a second one " in the left groin close to the base of the scrotum ". The appearance of these fistulæ at such a late date was presumed to be due to peri-urethral abscesses. The groin fistula rapidly closed, and the patient was discharged after five months. The refractory penile fistula occasioned four attempts at closure.

EXAMINATION 18 MONTHS AFTER THE INJURY.—The patient is very frail, and progression with two crutches is slow and difficult. He has much pain in the back and hips. There has been no bougie treatment since discharge from hospital, and there is now a good urinary stream, but pain at the end of the penis on micturition. Frequency: day, every five minutes; night, 3 to 4 times. The urine contains many phosphates, but no albumin or pus. The prostate appears normal. There have been no erections, and the patient states that his penis has atrophied since the accident. Yet the organ looks of normal proportions. Urethrogram shows an enlarged canal behind the corona, but no stricture or elongation of the membranous urethra. (*See Fig.* 216.)

Case 5.—F. H., aged 48 (July 26, 1933), skidded from his bicycle under a charabanc; dazed; brought to hospital within an hour.

There was extreme bruising and effusion from above Poupart's ligament down the inner side of the right thigh. No perineal tenderness. No blood could be expressed from the urethra; there was no evidence of intraperitoneal effusion or rupture. The pelvis was fractured—both ischio-pubic rami were separated from the symphysis. Catheterization produced clear urine with only a few microscopic red cells.

Two days later the extensive thigh effusion was tapped: 300 c.c. of blood-stained fluid were withdrawn, and found to contain 0·81 per cent of urea—obviously urine. A groin drainage was established, but as the patient appeared to have no difficulty in micturition it was deemed inadvisable to do more. A pyrexia of 101°–103°, and an occasional drop of urine from the groin, still persisted, so on the 15th day the bladder and urethra were X-rayed. The cystogram appeared normal, but urethrography showed a track of lipiodol extending from the membranous urethra to the groin.

An in-dwelling catheter was inserted, but caused acute pain and restlessness, so was removed. The groin sinus rapidly cleared up, and apart from an unexplained sharp rigor

at the end of five weeks, and pyrexia for the next seven days, the urinary convalescence was good. Owing to his fractured pelvis the patient remained in hospital for eleven weeks.

EXAMINATION 2½ YEARS AFTER THE INJURY.—Has not experienced pain or difficulty with micturition: day, 4 hours; night, nil; no sex disturbance. Urethrogram normal. No sign of any fistulous tract or stricture. (*See Fig.* 216.)

Case 6.—W. G., aged 42 (April 2, 1932). His van was struck by a skidding lorry, and he slipped down between the shafts. His horse kicked the end of his penis.

On admission twenty minutes later the patient was extremely shocked. The glans penis was a most gruesome sight. Swollen to the size of an orange, it was plum-coloured and dripping with blood. There was a deep T-shaped laceration, the horizontal bar running around the corona and partially severing the glans from the shaft, the vertical bar completely laying open the distal part of the urethra up to the meatus. The remainder of the penis was much bruised.

Immediate operation. Toilet. Suture of urethra in two layers around a self-retaining catheter, and of the glans to the shaft. Sprengel's pump to catheter.

All the sutures held except a few on the under surface near the external meatus. The date of removing the in-dwelling catheter was unfortunately not recorded, but the patient left hospital on the eighteenth day with a healed wound.

FIG. 218.—*Case* 7. Showing the enormous perineal fistula.

EXAMINATION 4 YEARS AFTER THE INJURY.—There has been no instrumentation since confinement in hospital, but the water very occasionally burns; day, 3 hours; night, once. Micturition is accompanied by much spraying of the stream, for there is a slight deficiency of the right extremity of the penis, with a very patulous external opening. On erection the glans balloons out to the left, pulling the frenum very taut and causing much pain. Ejaculations are "sideways". Coitus is only undertaken once in two months. There is no stricture.

Case 7.—X. Y., aged 27. Albumin in urine at the age of 12. Cystoscopy was said to be essential to eliminate tuberculosis. This was attempted, but followed by much urethral bleeding and the development of a stricture in the next six months. Repeated dilatations have since been necessary. At the age of 14, patient consulted a French surgeon, who diagnosed tuberculous epididymitis and gave injections, strongly smelling of creosote, into the testicle. Almost immediately afterwards "water" appeared in the right knee. A radiograph was negative. The limb was splinted and the patient soon returned to cricket, ski-ing, etc. At the age of 16, while at winter sports, the stricture again became troublesome. A peri-urethral abscess developed, and was opened and drained by a Swiss surgeon. A mid-line perineal catheter was inserted into the bladder behind the abscess. Tests for tuberculosis again were negative.

Last year the patient, aged 27, consulted the author for a now definite tuberculous knee and for a bulbar stricture with a long, irregular, and gaping perineal fistula behind it, through which urine sprayed on micturition (*Fig.* 218).

As the knee showed active disease it was considered the most urgent matter, and the patient was sent to an orthopædic surgeon. An excellent excision has produced a stable limb.

The urethra is now under consideration. The definite traumatic origin after cystoscopy long before the advent of suitably small children's cystoscopes, the non-advancement of the fistula during all these years, and the examination of the edge, all rule out tubercle as the source of the trouble.

The stricture itself and the elongated perineal fistula present separate problems. A suprapubic deviation preceding any operative measures by at least two weeks will be a necessary and safe preliminary. Cutaneous autoplastic flaps, such as Fruchaud's, are fortunately unnecessary here, and should only be used as a last resort where mobilization fails. Most of such flaps grow hairs.

Case 8.—A. D., aged 40 (May 7, 1930), stated that he caught his penis on his pyjama strings when getting out of bed one hour before admission. There was profuse bright bleeding from the urethra and a tender spot just behind the glans. Ice-bags were placed above and below the penile shaft, and a large dose of morphia administered. Cessation of hæmorrhage followed in twelve hours, and discharge from hospital in two days.

SIX YEARS AFTER THE ACCIDENT.—There has been no difficulty in passing water, and no catheterization has been necessary.

CONCLUSION.—Rupture of the mucous membrane of the pendulous urethra: of doubtful cause.

Table I.—SUMMARY OF PERSONAL CASES

Case Number	1	2	3	4	5	6	7	8
Age (in years) ..	70	25	5	47	48	42	12	40
Site	Bulb	Bulb	Memb.	Memb.	Memb.	Penis	Bulb	Penis
Cause	Astride	Astride	Car	Fall	Fall	Kick	Surgical instrument	?
Fractured Pelvis ..	–	–	1	1	1	–	–	–
Symptoms :—								
Shock	1	–	1	1	1	1	–	–
Pain	1	1	1	1	1	1	–	1
Bleeding from penis..	1	1	1	1	No	1	–	1
Perineal tumour ..	–	1	–	1	No	Penile	–	Penile
Perineal tenderness ..	1	1	1	1	No	Penile	–	Penile
Ecchymosis.. ..	1	–	–	1	1	Penile	–	–
Retention*	1	P	–	–	No	–	–	–
Extravasation ..	–	–	–	–	1	–	–	–
Treatment :—								
Suprapubic diversion	1	1	1	1	–	–	–	–
In-dwelling catheter ..	1	1	1	1	P	1	–	1
Duration	1 mth.	2 mth.	6 wk.	3 wk.	1 hr.	?	–	2 days
Perineal section ..	–	–	–	–	–	–	–	–
Sprengel	1	1	1	1	–	1	–	–
Complications :—								
Pus in urine ..	1	1	1	1	–	–	–	–
Abscess	1	1	osteomyelitis	P	–	–	–	–
Perineal fistula ..	1	–	–	1	–	–	1	–
Stricture	No	No	No	No	No	No	Yes,	No
Years followed up	2½	2½	4	1½	2½	4	but no treatment	6
Impotence	PP	Pain	–	1	–	–	–	–
Miscellaneous ..	–	Bladder stone	Bleeding per rectum	–	–	–	–	–
Hospitalization (in weeks)	12	9	40	22	11	18 days	–	2 days

* Most patients brought to hospital "under the hour"; retention therefore unlikely.
P = Presumed. PP = Partial.

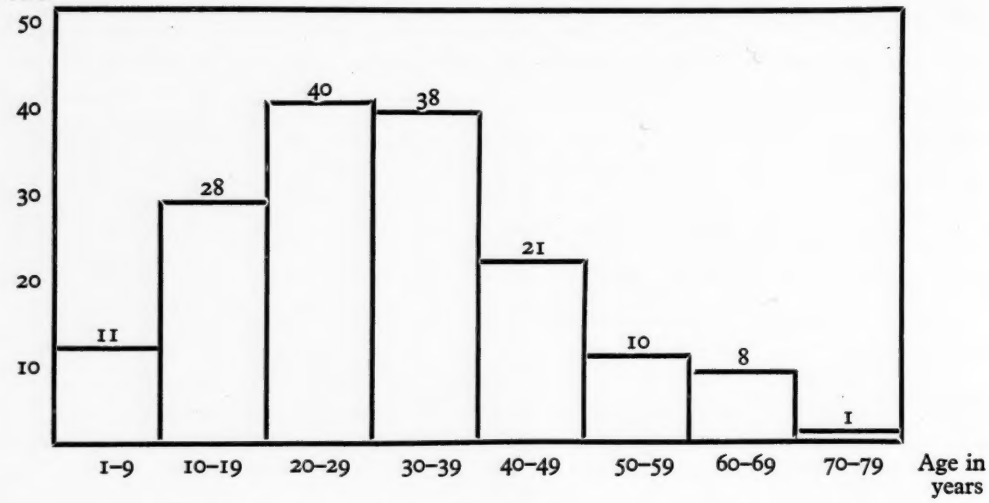
ETIOLOGY, BASED ON 381 RECORDED CASES

The ages, sex, sites, and causes of rupture in the 381 recorded cases are detailed in *Tables II* to *IV*, cases of rupture of the female urethra being shown in *Tables III* and *IV*.

AGE

The age is stated in 157 cases; unstated in 177 cases. The remaining 47 further cases comprise 15 " boys ", 1 " young student ", and 21 " adults ".

Table II.—Age-Incidence of Urethral Rupture



SITE

The term ' membranous ' in this paper and in the Tables embraces the whole of the posterior urethra from the bladder neck to the junction with the bulb (5 cm.), for at operation it is nearly always impossible to determine the exact site of the rupture owing to the astonishing amount of bruised tissue and blood-clot. Further minute differentiation is of little practical value.

Table III.—Site of Urethral Rupture

	Recorded	Presumed*	Total	Percentage of Total Cases
Bulbous	150	37	187	50
Membranous ..	114	42	156	40
Pendulous ..	19	–	19	5
Female	7	–	7	2
Site unstated ..	–	–	12	3
Total ..	..	..	381	

* Suggested and almost made certain by the other details of each record. In later tables it has been found inadvisable to separate the groups ' recorded ' and ' presumed '.

CAUSES

It will be observed in *Tables III* and *IV* how rarely the shaft of the penis (19) or the female urethra (7) is injured, and how responsible is fracture of the pelvis in producing membranous ruptures (107). Falling 'astride' a plank or pole nearly always causes injury to the bulb by driving that portion of the urethra sharply against the cleft of the pubic arch (157). It is remarkable, however, that this method may occasion injury to the membranous urethra (17). Falling heavily 'on the side' without fracturing the pelvis only produces 5 membranous ruptures, but such falls can actually cause bulbar (9) instead of the usual membranous lesions (112).

The list contains a few rare accidents, of which coitus, a string tied round the penis to stop a gonorrhœal discharge, and a solitary case of indirect violence are the most interesting. In the last a man tumbled from a lorry and in mid-air kicked up at a sack falling on top of him.

Table IV.—ACCIDENTS CAUSING URETHRAL RUPTURE

	BULB	MEMBRANOUS	PENDULOUS	SITE UNSTATED	TOTAL	PERCENTAGE
Falls :—						
'Astride'—e.g., a ladder rung, girder, or grating, edge of barge or buggy wheel, arch of saddle, engine buffer	157	17	–	–	174	46
'On side', without pelvic fracture—e.g., motor cycle wobble, knocked down by car	(6 + 3 = 9)	(107+5 =112)	2	3	13	3
'On side', with pelvic fracture—e.g., crushes, car accidents, falls from buildings ..			–	–	113	30
Blows :—Direct hits on perineum—e.g., kick from human or horse, sledge-hammer, barrow handle, car handle 'knocking' violently on perineum[35]	9	7	–	4	20	5
Instrumental :—Surgical catheter or cystoscope (7)[9]; self-inflicted dement (1); irrigation with lipiodol (2)[40]; with argyrol (1)[40] ..	11	–	–	–	11	3
Miscellaneous :—						
Coitus[20, 26, 43, 63]	–	–	4	–	–	–
Shot in stooping position[39]	–	1	–	–	–	–
Penis whirled off in machine (1)[43]; twisted (3)[20]	–	–	4	–	–	–
String tied round penis[20]	–	–	2	–	–	–
Indirect muscular violence[30]	–	1	–	–	12	3
Female :—Car accidents with fractured pelvis (5)[69]; blow (1)[47]; coitus (1)[3]	–	–	–	7	7	1
Cause unstated	1	18	7	5	31	8
Totals	187	156	19	19	381	

Of the females, the sad state of a young woman of 23 is recorded. An attempt at coitus on her bridal night was followed by severe pain, abundant hæmorrhage, and incontinence, the latter persisting for three long months, during which

Read :—

Falls :—						
'On side', without pelvic fracture—e.g., motor cycle wobble, knocked down by car	3	5	2	3	13	3
'On side', with pelvic fracture—e.g., crushes, car accidents, falls from buildings ..	6	107	-	-	113	30

time the patient kept mostly to her bed. On examination a finger could be introduced " with great ease and without pressing " up the urethra into the bladder. It is interesting to note that two operations were necessary to close the defect. At the first an in-dwelling catheter was used, but at the second a suprapubic derivation was performed and continence restored.

It is odd that there are only 2 female ruptures in the literature apart from no less than 5 occurring in the practice of Turley; all the five are said to be due to automobile accidents.

The irrigation disasters are included as curiosities; Jules Janet reported them as " ruptures ", for each patient suffered a sharp burning sensation, and the penis was swollen and blue-red immediately after the injection. One followed the injection of argyrol 20 per cent, one lipiodol for urethrography, and another lipiodol for chronic stricture. These are happily the only three such records during the past twenty years, and it is singular that they are all reported by the same author.

TYPE

The type of urethral rupture depends on the degree of damage inflicted.

In *partial* ruptures either the mucous membrane alone is torn, as in penile injuries (e.g., *Case* 8), or more commonly part of the tube may be split across (e.g., *Cases* 1 and 2).

In *complete* ruptures a blow sufficient to sever the tough urethra usually causes much crushing of the ends, and the gap thus formed is further increased by the retraction of the elastic tissue.

' *Compound fractures* ' of the urethra arise as a result of severe perineal laceration by blunt instruments. One intoxicated man who had fallen asleep on the road was carried some distance by the starting-handle of a car " knocking violently on his perineum ".

SYMPTOMS AND SIGNS

The symptoms of traumatic rupture are few and straightforward, and, except when submerged in grosser pelvic damage, readily lead to a correct diagnosis. This is reflected in the short consideration given to symptoms in the recorded cases—in well over three-quarters of the total 381 these details are omitted altogether. Shock, pain, bleeding from the penis, perineal hæmatoma and ecchymosis, abnormality of micturition, and occasional extravasation, form the principle symptoms.

Shock is severe even when the extreme end of the penis alone is injured (cf. *Case* 6).

Pain may be absent on account of the shock, or obscured by the agony of a pelvic fracture. In uncomplicated cases it is usually felt in the perineum, but may radiate to the tip of the glans.

Bleeding from the penis is often stated to be more profuse in partial than in complete ruptures, for it is maintained that the wide and irregular separation of the torn ends prevents the escape of blood down the normal urinary channel (Legueu). The series shows this observation to be of more theoretical than practical value, for several cases with considerably retracted ends poured with blood. This even occurred where enormous reaches of the pelvic floor had been

torn up and gaping chasms had been filled to overflowing with bloody fluid (cf. *Cases* 3 and 4).

Table V.—SYMPTOMS OF URETHRAL RUPTURE

SYMPTOMS	NO. OF CASES*
Retention	95
Penile bleeding	69
Perineal hæmatoma or tumour	73
Perineal ecchymosis	45
Perineal or penile pain ..	36
Extravasation of urine ..	35
Shock	27

*These figures are very small, for in over three-quarters of the 381 cases no symptoms were recorded.

Perineal hæmatomata have been tied down to rigid anatomical planes—and are affirmed to occur only in ruptures below the triangular ligament. Such hæmatomata are governed more by the severity of the injury, and by the lapse of time, than by anatomy. A crush or fall sufficient to fracture a pelvis, or indeed a tough urethral tube, is not likely to respect fascial boundaries, and blood may fill any nascent cavity or gravitate to the perineum. Wheeler is one of the few who have emphasized the possibility of a perineal hæmatoma being due to a tear above, as well as below, the barrier of the triangular ligament. Again, cases not seen for two to even seven days will have had ample time for blood to collect in the dependent parts.

Case 4 had no hæmatoma when examined in the surgery, but an incredible perineal tumour was present on arrival at the ward. This had actually overflowed to the scrotum by the time the patient was on the operating table—only about an hour after the injury.

Another type of hæmatoma present in membranous ruptures, and very seldom stressed, is the soft boggy mass which can be felt bulging into the rectum and occupying the place of the prostate when the latter has been wrenched from its bed (*Fig.* 219).

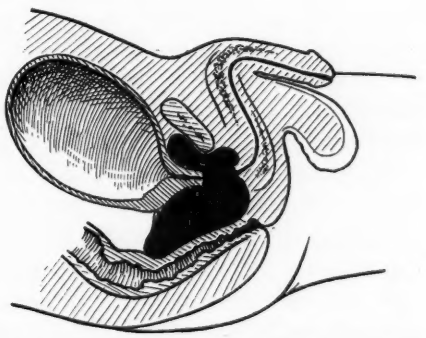


FIG. 219.—Shows the large hæmatoma which can often be felt as a boggy mass per rectum.

Ecchymosis may be expected in all blows or falls astride where direct violence in inflicted on the perineum, yet it is also found in posterior injuries. Of 45 recorded cases 28 were bulbous and 17 membranous, but as 6 of the latter were due to falls astride, and therefore to local bruising, the correct proportion might be interpreted as 34 direct to 11 indirect injuries. It is interesting to note that the solitary case of indirect violence, i.e., kicking up at a falling sack, and only 3 of the author's series (2 membranous, 1 bulb), presented this perineal staining.

Abnormality of micturition: The term 'retention' of urine has been too widely used to embrace all urinary difficulties. At the one end of the scale patients have been able to pass water fairly well for days, and then real retention has gradually

overcome them. All such cases are not limited to partial ruptures. Smith and Mintz record a remarkable case of complete separation of the torn urethral ends where the patient passed water for six weeks before complete stoppage occurred. Barnett records cases of 13 days, Morison 10 days, and Jastram 8 days before cessation. Flandrin records a case of a patient who fell astride, continued work, went to bed without voiding, passed a good night, and was harassed at not being able to micturate the next morning. This is quite a common experience. Intermediate cases have painful and frequent passage of blood-stained urine.

At the other end of the scale there is sudden and absolute retention which is intensified by frequent wild attempts to void, and sometimes rewarded by the squeezing out of a few drops of blood. In these cases full bladders can usually be palpated provided the lower abdomen is not thrown into spasm by fracture of the pelvis.

Of the meagre symptoms supplied by the records, " retention " or " inability to void " seem to have impressed the writers the most.

Extravasation of urine should seldom occur if a diagnosis of rupture is made *early* enough. The bladder sphincters fortunately nearly always escape, for they usually lie above the site of rupture; a protective sphincteric spasm can thus prevent the soiling of the injured field. When extravasation occurs, however, there is a strong tendency for the tissues rapidly to necrose, and for the penis, scrotum, and perineum to become œdematous, blue-black, and dotted with greyish sloughs or wholesale gangrene. Hamilton Bailey and Huddy state that 22 per cent of traumatic ruptures have extravasation, and when this occurs the mortality increases to 20 per cent.

DIAGNOSIS

The passage of a catheter is the most unreliable means of diagnosis, and this should not be employed. Numerous examples of the false information it gives are to hand. Young chides himself for not operating on a patient whose bladder could be so easily catheterized that a membranous rupture was missed until a fatal sepsis allowed the true condition to be revealed post mortem. Wheeler delayed operating upon a ruptured bladder for twenty-four hours because repeated catheterization withdrew a full quantity of blood-stained urine. At operation he was able to demonstrate that the sound had passed through the rent in the bladder into the urine-laden peritoneal cavity.

There are no less than 42 cited occasions when diagnostic catherization was unsuccessful. In only 6 cases was this manœuvre definitely forbidden.

In the rare accident of double rupture, bladder and posterior urethra, operation alone (or autopsy) discloses the dual injury—e.g., Berry's Case 2; Peacock and Haines's Case 1 (died) and Case 3 (16 operations for repair).

Lipiodol urethrograms sometimes are of use in diagnosing doubtful cases—e.g., the author's *Case* 5, Partsch and Breitländer's Case 4.

Air injected up the penis has been used by Vaughan Reid to differentiate urethral and bladder injuries. He possesses pictures of air passing out of cystostomy rents and bubbling up between the coils of small intestine. In an article in preparation the author shows that even oxygen is not absolved from the remote danger of air embolus.

COMPLICATIONS AND CONCOMITANT INJURIES

Table VI conveys a good idea of the various types of complications that are to be expected, and beyond a consideration of the most serious difficulty—*stricture formation*—no further allusion to them will be made.

Table VI.—Complications and Concomitant Injuries in Ruptured Urethra

Lesion	No. of Cases
Stricture	100
Sepsis :—	
Wound	70
Urethral fistula	37
Periurethral abscess	13
Osteomyelitis of pelvis	2
Intestinal fistula	2
Stone : Bladder (4) ; Urethra (3)	7
Second and subsequent operation (one of these cases had 16 operations)	40
Epididymo-orchitis	9
Gangrene of genitals :—	
Penis	7
Scrotum	5
Laceration of genitals	3
Severe additional injuries :—	
Bladder	4
Rectum	4
Spine	5
Skull	1
Mention of impotence	10
Recorded deaths (mostly with fractured pelvis) ..	24

Care must be exercised in not looking upon the figures as a true percentage representation, but rather as an indication of the proportional value of any one complication. Thus 100 cases are actually admitted as having strictures and represent the minimum of such a complication. Of the remainder either their progress since discharge has not been given, or an overwhelming majority of those with adequate follow-ups have undergone repeated and regularized catheterizations. In fact the impression gained by this survey is that the shadow of stricture formation is a very ominous one, and it is hardly an exaggeration to state that the case of ruptured urethra that escapes long ' bougie ' treatment must be the great exception rather than the rule. Kidd mentions that out of 26 follow-ups only one could be proved to be stricture-free, but later adds that of 25 complete ruptures 76 per cent were " practical " cures. Pasteau and Iselin mention only 3 out of 35 cases of urethral strictures as cured. The most tragic story of a strictured life is one of a patient who regularly catheterized himself every day for sixty-five years following a rupture, and finally succumbed to a carcinoma on that part of the bladder which had received a daily touch from the head of the instrument (Stirling).

Table VII.—Analysis of 100 Cases of Stricture

	No. of Cases
Site :—	
Bulb	38
Membranous	44
Uncertain*	18
Cause :—	
Falls 'astride'	36
Falls 'on side' without pelvic fracture ..	2
Falls 'on side' with pelvic fracture	36
Blows	5
Instrumental (1), unstated (20)	21
Treatment :—	
Suprapubic drainage	36
Perineal section	71
End-to-end anastomosis	36
In-dwelling catheter	79
Perineal wound drainage	31
Sepsis :—	
Wound	34
Fistula	25
Abscess	7
Extravasation :—	
Hours from accident to operation—under 24 ..	18
Hours from accident to operation—under 48 ..	5

* This figure is higher than the 'unstated' cases in *Table III*, for it is often noted that "out of a total of, say, 6 cases (4 bulbs, 2 membranous) there were 3 strictures", and no indication is given as to which type is meant.

A little comfort, however, can be extracted from this general gloom in that the word stricture is loosely used in two respects. First, a few cases are dubbed 'stricture' when a catheter fails to be passed during the early convalescence, and hurried retrogressions of sounds are done. Secondly, a 'soft' stricture is an unfortunate title. In the author's series, *Case* 3 showed a 'soft' stricture on uroscopic examination at the eighteenth month, but the largest catheter his penis could carry slipped through the posterior urethra with the greatest ease. Four years later, with no intervening dilatations, there is no suggestion that the 'soft' stricture has interfered with micturition or with the urethrogram. Urethroscopy to-day would doubtless show the soft diaphragm; it might tempt the anxious to advise a long course of bougie treatment and to record the case without qualification as a 'stricture'.

Ralph Thompson and Lowsley give excellent summaries showing why traumatic strictures are worse than gonococcal ones, Thompson also stressing the serious nature of rupture in children.

RECORDED TREATMENT

It is impossible here to present every type of treatment employed in the 381 cases.

A *general* analysis (*Table VIII*) discloses that the perineum was incised in no less than 248 cases, and the bladder was opened in only 181. In but a few of

these 181—notably Banks's cases—was the bladder definitely recorded as closed at the end of the operation, and so 181 represents the very maximum of urinary deviation, i.e., just under 50 per cent. The in-dwelling catheter was used 180 times. In 105 cases it was employed as a splint to ensure the patency of the urethra, for a temporary suprapubic tube drew off the urine; in the remaining 75 cases the catheter alone served the dual purpose of splint and drain.

Table VIII.—TREATMENT OF RUPTURED URETHRA

TREATMENT	NO. OF CASES
Perineal section	248
End-to-end anastomosis	141
In-dwelling urethral catheter :—Membranous (92); bulb (83); penile (2), female (3)	180
Perineal wound drainage	41
Suprapubic drainage	181
Perineal bladder drainage proximal to suture[51, 63, 71]	3
Urethral ends stitched to perineal skin ..	16
Ends too far apart to suture: Bridged by hinged urethral flap (3)[70]; bridged by fascia lata (2)[11, 51]; bridged by saphenous vein (1)[51]; left alone (6)	12
Use of silk or wax thread mandrin[34, 48, 52] ..	3

An *individual* analysis, however, justifies the following observations. There is almost universal agreement that bulbar and membranous ruptures should be differently treated. It is often stated that the deep situation and much less tendency to stricture formation of the membranous urethra submits more kindly to the in-dwelling catheter, yet it ought to be noted that the major portion of the 100 strictures implicated the membranous region. Bulbar injuries arouse argument as to the necessity for suprapubic deviation, the help or harm of an in-dwelling catheter, and whether or not an external urethrotomy should be made.

Marion emphasizes that immediate external urethrotomy (which he advocated in 1914) has no indication in traumatic rupture of the urethra. He prefers an instant suprapubic drainage as inaugurated by Rochet of Lyons. For membranous ruptures he relies on an in-dwelling catheter to maintain the axis of the channel, and in the large majority of such cases feels that perineal section is unnecessary. It should be reserved for the very few that develop strictures at a later date. In them a formal excision of scar tissue and end-to-end anastomosis can be performed, this time discarding the in-dweller on completing the suture. For bulbar injuries Marion dislikes anything more than simple deviation for six weeks. The perineum is now in a fit state for exploration and end-to-end suture over a resident sound. The urethra is rid of this sound at the end of the operation and convalescent bougie treatment is avoided. Marion is supported in his delayed operation by Coppidge, Raynaud, and others.

Young utilizes the in-dwelling catheter for both varieties, and reserves a suprapubic operation for retrogression, when desired, and for extravasation. He favours an immediate perineal incision, mid-line for the bulbar variety, and inverted V with

division of the central tendon and recto-urethralis muscle for the membranous lesions (*Figs.* 220, 221). Badly lacerated tissue is excised, and ends anastomosed or partial defects closed round a catheter which remains in situ for a week or more.

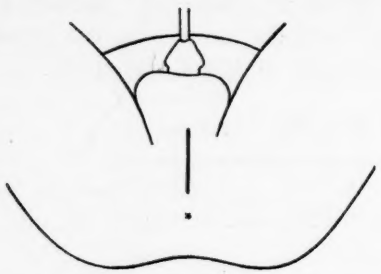


FIG. 220.—Young's incision for bulbar lesions.

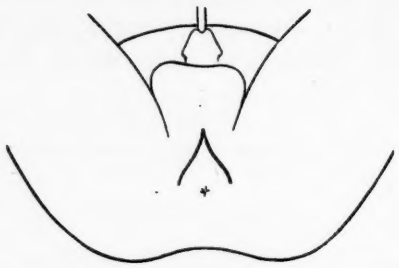


FIG. 221.—Young's incision for membranous lesions.

Young's method of repairing a membranous lesion is shown in *Figs.* 222–223, A, B. Where large urethral gaps occur it is only necessary to suture part of the mucous membrane over a large catheter.

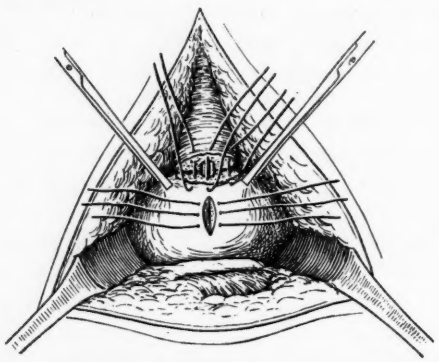
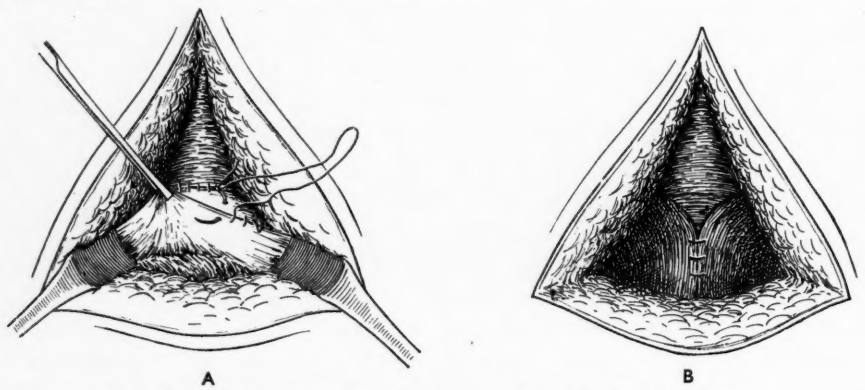


FIG. 222.—Young's method of repairing a membranous lesion. The radiating sutures do not pierce the mucous membrane. The small 'prostatic' incision draws off the urine, and allows a catheter to be passed down the urethra to find the damaged proximal end. An in-dwelling catheter remains in situ for seven days.



A B

FIG. 223, A, B.—Young's method of closure of the deep wound in layers.

Legueu also operates at once, but condemns the in-dweller as a source of sepsis, and supports his contention by quoting experiments, in conjunction with Guyon, on dogs. His fear of stricture formation compels him to suture the bulbar

ends to the perineal skin. In the large majority these ends apparently sink back into their normal ' reconstructed ' position, but in the few recalcitrant cases autoplastic measures overcome the difficulty. Pasteau and Iselin support, and have popularized, Legueu's skin-suture method.

The in-dwelling catheter has been avoided by Alamartine, Cabot, Grey Turner, Garlock, Legueu, Pasteau, Iselin, and Rochet; but Banks, Becker, Smith, Mintz, and the majority of English and American writers have joined Young in favouring this catheter, not only for drawing off the urine, but also for maintaining the patency and splinting of the axis of the urethra during the healing stage.

In late septic cases, the reluctance to use the catheter *à demeure* appears to wane. Attwater maintained a catheter in such a type for four months with good effect, and his action has been endorsed by many of the French school.

Banks's simple but ingenious manœuvre may be used where the in-dweller seems to be of more accepted use, i.e., in membranous ruptures, and completely disposes of a perineal section. One metal sound with a cupped beak is retrograded through a tiny suprapubic incision. Another sound with a round tip is ' antegraded ' through the penis. A hand on each instrument carefully manipulates these together so that the rounded end fits into the cupped one. The sounds are then kept in firm apposition and gently swung round so that the penile instrument protrudes through the bladder wound. A soft rubber catheter is now tied to a small hole at its tip and pulled down the urethra as an in-dweller. The bladder is then closed.

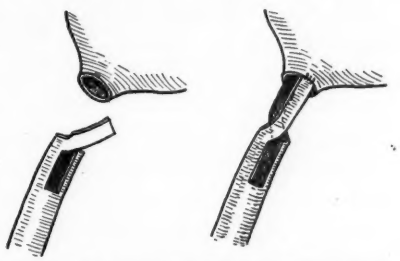


FIG. 224.—Watson's method of swinging round two lateral urethral flaps to bridge a gap.

Difficulty in replacing in-dwelling catheters has led some authors to pass a filiform bougie up the lumen of the old catheter before withdrawing the latter. A new rubber one has then been easily threaded over the central guide. McWhorter has employed with effect a wax silk mandrin. The loose ends hang from the penis and bladder and the suprapubic wound rapidly granulates around the latter. In one case this tiny seton remained threaded through the in-dweller up to the 5th day, and facilitated the guidance of dilating sounds along its path until the 65th day. The ' railroad ' method of replacing catheters is too well known to be described here; it suffers the disadvantage of having to be catered for at the original operation.

Failure to pass a bougie has been variously circumvented. Marion is prepared philosophically to wait a few more days until the reactionary œdema has settled down rather than attempt to pass a catheter a second time at one sitting. A curved Béniqué after the Buckston Browne style will now often negotiate the slight angulation of a urethral axis which a straight catheter cannot explore. The gentle ' clocking of the compass ' by one filiform; the simultaneous passing of several filiforms, each one in turn being coaxed a little further down the urethra until one eventually finds the proximal channel; and special urethroscopic instruments for passing a sound under direct vision (Lowsley, Raynaud),—have all been used to overcome the difficulty.

The few *flaps* that have been fashioned to bridge gaps indicate their extremely rare and doubtful application. One inventive method is given (*Fig.* 224), but a perfection of the author's weight extension method avoids the necessity for cutting into the normal urethra to make the flaps.

The penile injuries have presented no difficulty except that a 'nasal' cautery was used to sear the site of one furious 'coital' bleeding.

Extravasation when it occurs must be given priority over all attempts at repair. Hartman's and Marion's methods of dealing with it are shown in *Figs.* 225, 226, A, B.

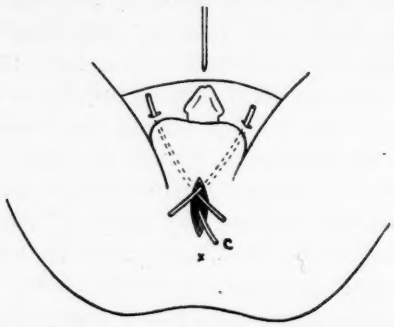


FIG. 225.—Hartman's method of dealing with severe extravasation of urine. The bladder is drained from the perineum by the catheter, C.

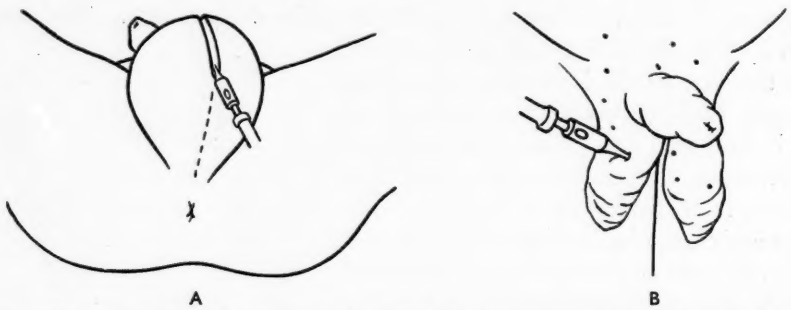


FIG. 226, A, B.—Marion's cautery method of dealing with severe extravasation of urine.

DISCUSSION

Successful anastomosis in the colon is so dependent on a good blood-supply that moderate sepsis or filthy bowel contents seem to be of lesser account. It might well be supposed that the rich vascularity of the other excretory channel would even more ensure recovery of extensive urethral injury or infection, and it is surprising to find strictures so common. An inherent tendency to scar-tissue formation or a damage to nerves—impotence and atrophy figuring so little—are causes which can be dismissed almost as certainly as the circulatory one. *Sepsis seems to be the one tangible cause which is capable of control.*

Causes of Sepsis.—Sepsis may arise from the following: (*a*) The urine; (*b*) The in-dwelling catheter; (*c*) Haphazard ascending catheterization; (*d*) Proximity of perineal wound to anus; (*e*) The extensive bruising and hæmatoma formation; (*f*) Concomitant injuries.

The Urine.—When urine repeatedly passes over a raw area it invites the septic necrosis familiar in extravasation. Protection must therefore occur both before and after surgical intervention.

Ambulance men and house surgeons will do well to warn patients not to pass water, and specimens should not be secured just to see whether bladders or urethræ are intact.

At operation, the most certain way of abstracting the urine should be employed. Thomson-Walker has shown that urine leaks along an evacuating catheter, so it seems logical to do a suprapubic deviation in all cases, partial or complete. Injuries of the pendulous urethra are the only possible exceptions. Marion deserves credit for emphasizing the need for suprapubic drainage, and Hugh Cabot condensed the subject best to the author in 1931 by saying—" when operating on any waterworks you must divert the stream ".

If any reason prevents immediate admission to hospital, repeated suprapubic aspiration through a long needle is an excellent step. The case of a sailor whose injury occurred five days from port, and whose bladder was regularly tapped by the ship's surgeon, cannot be quoted too often, for not the slightest sign of extravasation could be found at the major operation ashore.

The In-dwelling Catheter.—The in-dwelling catheter as a source of sepsis has been condemned on the grounds that even the normal urethra becomes septic when a catheter is tied in for three to four days. In its condemnation Grey-Turner expresses the view-point best by stating that no foreign body, such as a catheter, must come into contact with the urethral wound during healing. The present paper suggests that as no less than 80 per cent of the 100 strictures (*Table VII*) harboured an in-dweller, the instrument may indeed be a cause of stricture rather than a cure.

Haphazard Anterior Catheterization.—Organisms can always be grown from the normal anterior urethra, and careless ' sounding ' will carry these up to any raw area; furthermore such sounding may inadvertently increase the damage. Catheterization must only be undertaken in the operating theatre where major surgery can immediately follow if necessary. In fact it is advisable to avoid ascending catheterization as a diagnostic measure. It is felt that a good history and physical signs are sufficient to justify a suprapubic cystotomy; whether the rupture is partial or complete is better established by gentle retrogression of a catheter down the urethra. Should the tip succeed in appearing at the penile meatus, the funnel end should be cut off and the catheter pulled downward and discarded, rather than be drawn up to risk meatal contamination. The abdominal incision has the added advantage of immediately allaying doubt about a ruptured bladder or extravasation.

One could only explain why the old man (*Case* 1) made such a splendid recovery and the healthier young man (*Case* 2) had such a septic course on some such grounds as this. The one difference in the treatment of these two *partial* ruptures—both operated upon within an hour of the accident, and both even subjected to an immediate suprapubic urinary diversion—was in their catheterization. In *Case* 1 retrogression alone was employed; in *Case* 2 ' antegression '. It is unlikely that the one preliminary voiding of ' sterile ' urine in *Case* 2 fouled the track, and so the ascending catheter must be suspected as the vehicle of infection.

Proximity of Perineal Wound to Anus.—The perineal skin is a poor site, especially when bruised, for aseptic exploration or external urethrotomy.

Extensive Bruising and Hæmatoma Formation.—These sources of sepsis are generally admitted. The opening of the perineum, removing pulped tissue and blood-clot, and leaving in a small drain to evacuate the oozing of the first twenty-four hours, therefore might be considered an advantage, but the dangers of increasing the sepsis by anal contamination, of excising too much damaged tissue on account of the impossibility of knowing how much is going to recover, and of

finding a poor foothold for exact end-to-end sutures, all suggest that operation may well be postponed till adequate resolution and absorption of blood-clot has occurred. Large perineal hæmatomata alone require evacuation at the preliminary derivation.

Delay in Treatment.—So great are the dangers of infection and extravasation that a ruptured urethra should be considered as much an emergency as a ruptured peptic ulcer. An adequate blow or fall with penile bleeding, or even repeated desire to micturate, should be sent to hospital for urgent attention and possible diversion of the urinary stream.

Concomitant Injuries.—Ruptures of the rectum have been recorded by Berry, Haines, Jastrum (Case 12), Young, André (female). Where these patients have recovered from such grosser damage—in one, the abdominal aorta could be seen from the perineum—the rectal wound has healed very promptly but the urethra has occasioned late anxiety.

CONCLUSION

Excluding the exceptional lacerations just described, and whose severity makes them purulent from the beginning, careful attention to detail will do much to reduce the toll of sepsis.

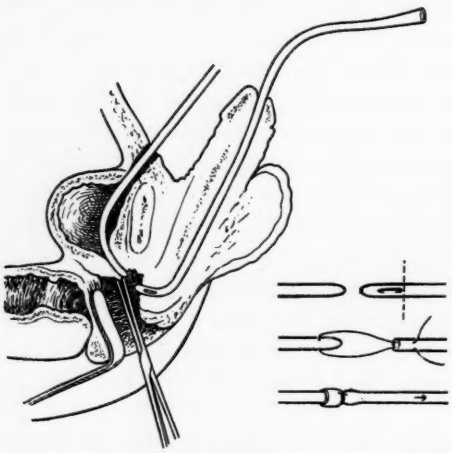


FIG. 227.—Showing a side view of the perineal approach to the membranous urethra, and the method of joining the catheters to enable one to be pulled down the urethra to act as an in-dweller.

In All Cases.—Success will depend on :—

Admission to hospital as soon as possible after the accident and before micturition has been allowed.

A careful toilet of any proposed operative site, particularly of the perineum, penis, and anterior urethra.

The prompt diversion of the urinary stream by a suprapubic incision, if necessary under a local anæsthetic.

The retrogression of a 'boiled' gum-elastic catheter down the urethra to establish a diagnosis of partial or complete rupture, and the discarding of this catheter from the meatal rather than the bladder end.

The wrapping of the penis in a sterile dressing which cannot fall off, to prevent ascending infection during the healing stage.

The high blocking of the foot of the bed (allowing several pillows under the head for comfort), to ensure the urine flowing away from the meatus into the fundus of the bladder.

The attachment of a Sprengel's pump to the suprapubic tube.

In Membranous Ruptures.—The disquieting figures of *Table VII* reveal that stricture is just as common in the membranous urethra as in the bulb, and as an in-dwelling catheter has formed the major treatment, almost 80 per cent of these cases, it would seem fair to question its propriety and to suggest it may well be replaced by a simple instant suprapubic drainage and a formal late repair. If an in-dweller is still preferred, it should be inserted, where possible, by retrogression, without resorting to a perineal incision to guide the catheter across the ruptured site.

Should this be difficult, an ascending catheter, after suitable lavage, and according to the method of Banks, will assist in straightening out the distal end for the reception of the descending catheter.

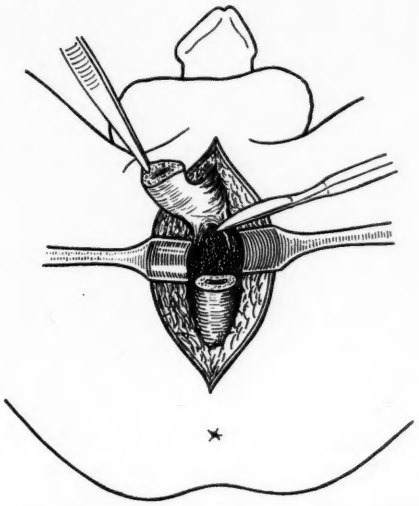


FIG. 228.—Marion's method of mobilizing the distal urethra to overcome the gap left after excision of the traumatized area.

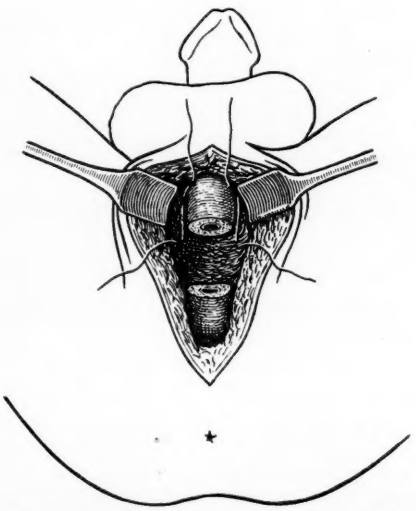


FIG. 229.—Marion's stay-sutures, when tied, draw the distal end up to the proximal one. Additional long mattress sutures can be inserted on the outside of the urethra to relieve the tension on the small radial sutures (*Fig.* 230), much as in the repair of a cut tendon.

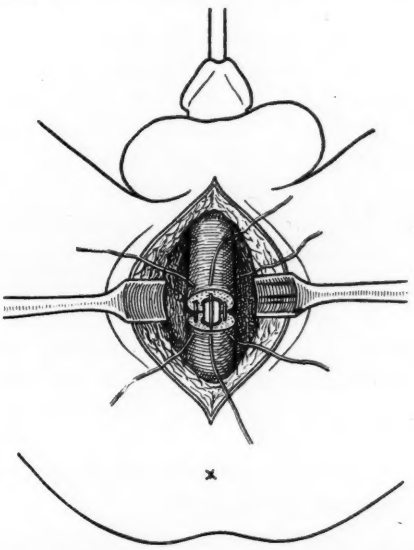


FIG. 230.—Marion's stay-sutures tied, the ends approximated and the small radial sutures inserted so that they do not pierce the mucous membrane. The in-dwelling catheter is discarded at the end of the operation.

The author's method of avoiding primary perineal incision by seizing the ascending catheter from the depth of the suprapubic wound and joining it to the retrograded one may be used when there is a dislocation of the prostate or separation of the symphysis pubis (*Cases* 3 and 4). The pulling down of the bladder and thus eliminating any gap between the torn ends, by a spring apparatus (similar

to a prostate bag-spring) or weight extension (as devised for *Case* 4), is a logical attempt at avoiding further surgery. Such a method is simple and extraordinarily well tolerated by the patient, but has only been used once, and is not free from the assumed disadvantage of an in-dweller.

When the perineal approach is used, the necessary steps of the operation and the method of uniting the catheters are shown in *Fig.* 227 and *Figs.* 221–223 B.

In Bulbar Ruptures.—The in-dwelling catheter is discarded and the best means of diverting the urine (a suprapubic) is essential for a varying period up to six weeks. A more certain union of the torn fragments is then possible. The freshened ends are united by small radial sutures to prevent angulation or mal-alignment, and tension is removed from these binding sutures by long mattress stitches placed on the outside of the corpus spongiosum, much as in the repair of a cut tendon. Marion's manœuvre (*Figs.* 228–230) should be employed to mobilize and fix the distal end if there is any doubt about tension or the traversing of gaps.

The anastomosis completed, the deep wound is closed in two or three layers, and a small drain inserted for twenty-four hours at the posterior end of the skin wound to control any temporary exudation. The patient is nursed with his legs wide apart (contrast the healing of an axillary wound with the arm abducted and to the side), and the bowels are constipated for five days. Each motion induces another toilet of the wound and change of dressings.

There is no urethral catheterization for 14 to 21 days, and on the first occasion it is accompanied by an anterior urethral wash-out under local or general anæsthesia to allay pain and spasm.

The suprapubic wound should only be allowed to close when the urethra is completely healed and free from catheter difficulty.

Any such difficulty is best dealt with by direct urethroscopy. Obstruction such as a small scar-tissue sail can be treated, or the proximal end can be seen to allow the gentle introduction of the first bougie of serial dilatators. The watchword '*doucement*' is at all times appropriate.

In Penile Ruptures.—Penile ruptures are happily rare, and except in extensive lacerations respond readily to simple means.

In Female Ruptures.—These must be just as carefully handled as bulbar injuries in the male. In-dwelling catheters are not well tolerated, and suprapubic cystostomies are preferred as soon as possible.

SUMMARY

1. Details are given of 8 personal cases and 381 recorded cases of traumatic rupture of the urethra.

2. The diagnosis is nearly always easy, and can be obtained from the history of an ' adequate ' accident and from the simple physical signs. Passing a catheter is a most unreliable means.

3. Difficulty is only experienced in grosser injuries to the pelvis, spine, or rectum, for here the bladder or urethra may also be involved.

4. The physical signs are shock, pain, bleeding from the penis, perineal hæmatoma, ecchymosis, and abnormality of micturition.

5. Stricture formation is more common and serious after traumatic ruptures than after any other type. In this series stricture appears to be as common after membranous as after bulbar injuries.

6. Sepsis is suggested as the one cause of stricture formation which can be controlled.

7. The various methods of repair are summarized.

8. Treatment is urged as soon as possible after the accident, and is directed against fouling of the raw area by urine, haphazard catheterization, or perineal contamination.

9. Suprapubic deviation is submitted as essential in all ruptures, partial or complete. The only exception to this rule is the rare injury to the penile shaft.

10. Posterior or 'membranous' ruptures are said to tolerate an in-dwelling catheter well and only a few cases produce strictures or require perineal exploration. The series does not endorse this general belief. Immediate perineal incisions are best avoided. A new emergency method of approximating the ends is described. Future treatment may more nearly approach that of injuries to the bulb.

11. Bulbar ruptures are certainly prone to stricture formation. In such lesions a suprapubic cystotomy is instantly performed, but a formal external urethrotomy is postponed until bruised tissue has recovered, necrotic tissue is well differentiated, and accurate end-to-end suture approximation has a better chance of 'holding' and healing.

12. Penile injuries are of less serious moment, and may not require a suprapubic operation.

13. Female injuries require immediate diversion of the urinary stream.

It is a pleasure to record my thanks to the late Mr. R. P. Rowlands for giving me *Cases* 1, 2, 3, and 5, and for urging me to publish the emergency measures used in *Case* 3; to Mr. Davies-Colley for allowing me to use a similar method on *Case* 4; to Mr. E. C. Hughes for *Case* 6 and Mr. O. L. Addison for *Case* 8. I am indebted to Dr. H. M. Worth for urethrograms of cases 1, 2, 4, and 5, to Dr. Bertram Shires for the urethrogram of case 3, to the Library staff of the Royal Society of Medicine for supplying me with books, to Mr. Steward of the Royal College of Surgeons for his beautiful diagrams, and to Miss Davies-Colley for the photograph.

REFERENCES

(The number of cases taken are shown in brackets at the end of the reference.)

[1] ALAMARTINE, M., *Lyon Chir.*, 1922, xix, 82. [1.]
[2] ALLISON, J. R., *Mil. Surgeon*, 1920, xlvii, 324. [1.]
[3] ANDRÉ, *Bull. Soc. d'Obst.*, 1932, xxi, 286. [1.]
[4] ATTWATER, H. L., and PREISKEL, I., *Lancet*, 1933, ii, 1424. [1.]
[5] BAILEY and HUDDY, *Brit. Jour. Surg.*, 1925, xii, 183. [Nil.]
[6] BANKS, H., *Ibid.*, 1927, xv, 262. [3.]
[7] BARNETT, C. E., *Urol. and Cutan. Rev.*, 1920, xxiv, 692. [2.]
[8] BECKER, J., *Arch. f. klin. Chir.*, 1934–35, clxxxi, 317. [20.]
[9] BERRY, N. E., *Canada Med. Assoc. Jour.*, 1930, xxii, 475. [32.]
[10] BESLEY, F. A., *Surg., Gynecol. and Obst.*, 1927, xliv, 372. [Nil.]
[11] BRENNER, E. C., *Jour. of Urol.*, 1924, xi, 197. [1.]
[12] CABOT, HUGH, Personal communication. [Nil.]
[13] CARRARO, D. N., *L'Osp. maggiore*, 1918, vi, 155. [1.]
[14] CLIFFORD-ABBOTT, A., *Canada Med. Assoc. Jour.*, 1929, xx, 634. [1.]
[15] COMBES, W. L., *U.S. Naval Med. Bull.*, 1921, xv, 407. [2.]
[16] COPPRIDGE, W. M., *South. Med. Jour.*, 1935, xxviii, 69. [8.]
[17] CUMSTON, C. G., *N.Y. Med. Jour.*, 1914, xcix, 10. [Nil.]
[18] DAVIS, R. T., *Surg. Gynecol. and Obst.*, 1927, xliv, 836. [1.]

[19] DEAN-BEVAN, A., *Surg. Clin. Chicago*, 1918, ii, 1131. [1.]
[20] DELZELL and STEVENS, *Jour. of Urol.*, 1935, xxxiv, 372. [35.]
[21] DUBOUCHER, M., *Bull. et Mém. Soc. nat. de Chir.*, 1926, lii, 1214. [1.]
[22] DUROSELLE, M., *Bull. et Mém. Soc. Chir.*, 1927, lviii, 142. [1.]
[23] EDMUNDS, A., *Med. Press and Circ.*, 1913, xcvi, 558. [1.]
[24] FIGUEIRA, M., *Long I. Med. Jour.*, 1918, xii, 194. [2.]
[25] FLANDRIN, P. R., *Jour. d'Urol.*, 1929, xxvii, 439. [3.]
[26] FLECHTENMACHER, C., *Zeits. f. Urol.*, 1921, xv, 73. [1.]
[27] FOULDS, G. S., *Canada Med. Assoc. Jour.*, 1930, xx, 365. [2.]
[28] FRANKENTHAL, L., *Zentralb. f. Chir.*, 1925, lii, 1598. [1.]
[29] FRUCHAUD, H., *Jour. d'Urol.*, 1934, xxxviii, 167. [1.]
[30] GARLOCK, J. G., *Surg. Gynecol. and Obst.*, 1923, xxxvii, 533. [1.]
[31] GREY-TURNER, G., *Lancet*, 1923, ii, 82. [Nil.]
[32] GRIMAULT, M. L., *Bull. et Mém. Soc. Chir.*, 1926, lii, 1232. [4.]
[33] HAINES, C., *Jour. of Urol.*, 1933, xxix, 285. [3.]
[34] HEITZ-BOYER, *Jour. d'Urol.*, 1935, xl, 438. [1.] *Bull. et Mém. Soc. Chir.*, 1921, xlvii, 584. [1.]
[35] HENRY, M. R., *Paris chir.*, 1920, xii, 267. [1.]
[36] HOLLANDER, H., *Berlin klin. Woch.*, 1918, lv, 219. [1.]
[37] HOPKINSON, H. C., *Lancet*, 1935, ii, 428. [1.]
[38] HUC, M. E., *Jour. d'Urol.*, 1934, xxxviii, 551. [3.]
[39] HUTTER, K., *Zeits. f. urol. Chir.*, 1935, xli, 260. [1.]
[40] JANET, J., *Jour. de Méd.-Chir. prat.*, 1935, cvi, 305. [3.]
[41] JASTRAM, M., *Deut. Zeits. f. Chir.*, 1923, clxxvii, 70. [12.]
[42] KESSELER, J., *Jour. d'Urol.*, 1932, xxxiv, 45. [1.]
[43] KIDD, F., *First Con. Soc. Inter. d'Urol.*, 1921, i, 169. [41.]
[44] LEGUEU, M. F., *Bull. et Mém. Soc. Chir*, 1927, liii, 92. [Nil.] *Bull et Mém., Soc. nat. de Chir.*, 1927. liii, 92. [47.]
[45] LOWSLEY, O. S., *Urol. and Cutan. Rev.*, 1935, Nov., 776. [Nil.]
[46] LUCCHESE, G., *Policlinico* (Sez. prat), 1934, xli, 1610. [1.]
[47] MANEN, S. A., *Anales de Pediat.*, 1934, vii, 442. [1.]
[48] MCWORTER, G. L., *Surg. Gynecol. and Obst.*, 1927, xliv, 247. [4.]
[49] MARION, G., *Traité d'Urologie*, 1935, ii. [Nil]. *Bull. et Mém. Soc. Chir.*, 1927, liii, 9. [Nil.] *Jour. d'Urol.*, 1914, v, 553. [10.]
[50] METRE, P. W. VAN, *China Med. Jour.*, 1916, xxx, 335. [1.]
[51] MORISON, R., *Surgical Contributions*, 1916, i, 271. Bristol: Wright. [2.]
[52] MURARD, M., *Lyon méd.*, 1921, cxxx, 738. [2.]
[53] PAPIN, M. F., *Bull. et Mém. Soc. méd. Bordeaux*, 1918. [1.]
[54] PASTEAU and ISELIN, *First Con. Soc. Inter. d'Urol.*, 1921, 124. [19.]
[55] PARTSCH, F., and BREITLANDER, *Zeits. f. urol. Chir.*, 1928, xxv, 108. [2.]
[56] PEACOCK and HAINES, *Jour. of Urol.*, 1926, l, 563. [1.]
[57] PLANZ, J., *Beitr. z. klin. Chir.*, 1934, clix, 111. [13.]
[58] POWERS, J. H., and SMITH, *N.Y. State Jour. of Med.*, 1932, xxxii, 1188. [2.]
[59] REYNARD, M., *Lyon méd.*, 1928, cxlii, 41. [1.]
[60] ROUSSEAU, M. F., *Paris chir.*, 1921, xiii, 233. [1.]
[61] SESHACHALAM, T., *Ind. Med. Gaz.*, 1932, lxvii, 85. [1.]
[62] SMITH, F. W., *Amer. Jour. Surg.*, 1916, xxx, 394. [1.]
[63] SMITH, G. G., and MINTZ, E. R., *Trans. Amer. Assoc. Gen.-Urin. Surg.*, 1931, xxiv, 241. [30.]
[64] SPURR, R., and MONTANARE, H., *Rev. d. Especialid.*, 1930, v, 117. [1.]
[65] STARLINGER, F., *Wien. klin. Woch.*, 1926, xxxix, 1515. [1.]
[66] STIRLING, W. C., *Jour. of Urol.*, 1927, xvii, 503. [7.]
[67] TANNER, E. K., *Long I. Med. Jour.*, 1918, xii, 273. [2.]
[68] THOMPSON, A. R., *Brit. Jour. Child. Dis.*, 1920, xvii, 70. [4.]
[69] TURLEY, H. K., *Urol. and Cutan. Rev.*, 1934, xxxviii, 772. [13.]
[70] WATSON, E. M., *Jour. of Urol.*, 1935, xxxiii, 64. [3.]
[71] WHEELER, Sir W. I. DE C., *Brit. Jour. Urol.*, 1929, i, 126. [7.] *Proc. Roy. Soc. Med.*, 1928, xxii, 1.
[72] YOUNG, H. H., *Practice of Urology*, 1926, ii, 595. [Nil.] *Jour. of Urol.*, 1929, xxi, 417. Nil..] *Zeits. f. Urol.*, 1929, xxiii, 419. [9.]

HYPERPLASTIC TUBERCULOSIS OF THE STOMACH CAUSING HOUR-GLASS DEFORMITY, WITH COMPLETE SQUAMOUS METAPLASIA OF THE UPPER LOCULUS

By G. W. WATSON, E. R. FLINT, and M. J. STEWART, Leeds

Hyperplastic tuberculosis of the digestive tract occurs most frequently in the region of the lower ileum, cæcum, and ascending colon, where it usually takes the form of a palpable mass with symptoms of chronic intestinal obstruction. Rarely, a similar form of the disease affects the pyloric portion of the stomach, again with the formation of a tumour and slowly progressive obstruction. In both sites, but more especially in the stomach, the clinical diagnosis is likely to be one of carcinoma.

The case which we now report is remarkable in that the granulomatous lesion has affected almost exactly the middle of the stomach, producing a high-grade hour-glass constriction, and there is the additional peculiarity that the mucosa of the upper loculus has been almost completely replaced by squamous epithelium. In a careful search of the literature we have failed to find any record of a similar case.

Fig. 231.—X-ray photograph taken on October 1, 1935, almost immediately after the administration of a second test-meal, the first having been given six hours previously. It shows a constriction of the middle portion of the stomach, with a large quantity of barium in the upper loculus and only a very small amount in the lower.

CASE REPORT

Clinical History.—F. S., a male, aged 31, was admitted to a medical ward of the General Infirmary at Leeds on August 21, 1935, with a three-months' history of epigastric pain, vomiting, and loss of weight. He was a tailor's presser, married, and had been deaf and dumb from birth. Vomiting of *undigested food* occurred about an hour after a meal and this afforded some relief to the pain, which was aggravated by the ingestion of more food. Both pain and vomiting became progressively more severe, and at the time of admission only small quantities of fluid could be retained. He had lost over a stone in weight. Prior to May, 1935, he had had no illnesses, and there was no family history of tuberculosis. He had always been a man of moderate habits.

On Examination.—During his stay in the medical ward he was thoroughly investigated, the salient points being as follows: He was emaciated and dehydrated. Physical examination revealed little beyond epigastric tenderness; no tumour could be felt in the abdomen, and there was no visible peristalsis. The bowels had been constipated only since the beginning of the illness. Micturition was normal and the urine contained no abnormal constituents. The Wassermann reaction was negative. On August 29 a fractional test-meal showed complete achlorhydria, with low total acidity and rapid emptying of the stomach. A blood-count on September 12 showed red blood-corpuscles

4,700,000, Hb 84 per cent, colour index 0·9, white blood-corpuscles 6,800. There were no abnormal features in stained films. X-ray examination on October 1 revealed a small narrow stomach with a well-marked stricture in the middle of the organ (*Fig.* 231). A small quantity of the barium meal was held up for some time at the cardiac end, and it was found impossible to fill the pyloric portion. The screen appearances suggested neoplasm. The œsophagus was normal.

On a diagnosis of carcinoma of the stomach, probably of leather-bottle type, the patient was transferred to a surgical ward for operation and was put on continuous intravenous glucose-saline for several days.

OPERATION.—This was performed on October 11 under spinal anæsthesia. The stomach presented itself as a short firm organ some six inches in length and not more than an inch across. There was a hard mass occupying the middle portion, and the whole organ was tucked up underneath the ribs. The cardiac end appeared fairly normal, except that it looked as though it would hold only about as much as a small coffee cup. The appearances as a whole were suggestive of leather-bottle stomach, yet the wall did not seem to be permeated in the manner characteristic of this condition, and doubt was felt and expressed as to the true nature of the lesion. There were no palpable glands. As the history and the radiological and chemical findings all supported the diagnosis of cancer, and since practically no useful part of the stomach was free from disease, it was decided to remove the whole organ. Even if it proved to be malignant there seemed to be a reasonable prospect that the whole of the disease might be eradicated. Total gastrectomy was accordingly performed and the œsophagus anastomosed to the jejunum, a loop of which was brought through the transverse mesocolon. The usual two layers of sutures were employed.

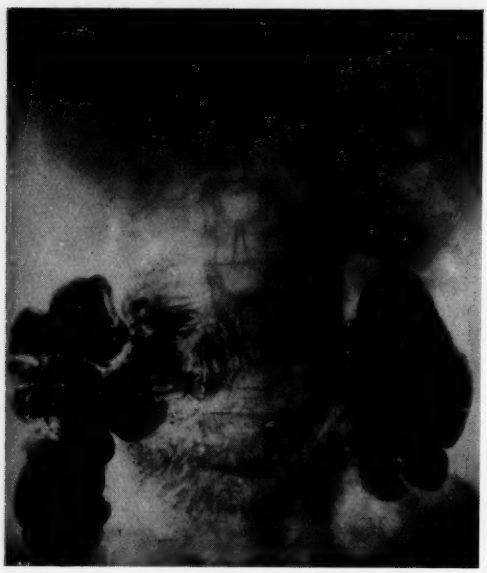


FIG. 232.—X-ray photograph taken on February 3, 1936, four months after total gastrectomy and immediately after the administration of a second test-meal. There is flooding of the loops of jejunum with barium, and no evidence of holding up in the œsophagus. The whole of the test-meal given six hours previously is collected in the cæcum and ascending colon.

AFTER-HISTORY.—The patient stood the operation well and made an uneventful recovery. Continuous intravenous glucose-saline was kept going for two days, until it was felt safe to allow fluids in sufficient quantity by the mouth. On October 24, thirteen days after operation, a blood-count showed red blood-corpuscles 4,100,000, Hb 80 per cent, colour index 0·9, white blood-corpuscles 7,500, with normal films. When discharged from hospital on November 20 he was making steady progress towards recovery.

The patient was re-examined on February 3, 1936. He was eating well, without restriction as to quantity or kind of food, and had gained half-a-stone in weight. A blood-count showed red blood-corpuscles 5,100,000, Hb 90 per cent, colour index 0·9, white blood-corpuscles 6,800, with normal films. Radiological examination showed no delay in the passage of the barium meal, which reached the cæcum in four hours. There was no appreciable dilatation of the small intestine near the anastomosis (*Fig.* 232).

DESCRIPTION OF THE GROSS SPECIMEN.—The stomach, the whole of which has been excised, is very greatly reduced in size, measuring no more than 4 in. along the lesser curvature and about 7 in. along the greater curvature. There is a notable constriction involving fully an inch of the middle of the organ, producing a well-marked hour-glass deformity. There is, however, no evidence of scarring on the serosal aspect nor of involvement of the peritoneum by new growth. When the organ had been laid open along the line of the greater curvature (*Fig.* 233) the central constriction was found to be due to a lesion of granulomatous aspect, causing the whole of the viscus to be much thickened (up to half an inch), leaving a lumen no

larger than a small quill. The lower loculus presented for the most part a normal-looking mucosa, except that the lesser curvature region for fully one inch below the constriction was the seat of ulceration of peculiar type. The margin of the ulcer was sinuous, red, and slightly undermined, the floor nodular and partly covered by a thin necrotic layer. The pyloric ring and adjacent mucosa appeared normal. The upper loculus presented an entirely different appearance. It had a smooth, white, firm lining at once suggesting squamous epithelium, except that along the line of the greater curvature there was a slightly projecting band of what appeared to be bright-red granulation tissue extending upwards for fully two inches. No gastro-œsophageal junction could be made out. In contradistinction to the lower loculus, the wall here showed great fibrous thickening of the submucosa. This appeared to be two to three times the thickness of the muscular coat, from which by reason of its whiteness it was very clearly demarcated, the muscularis being reddish in tint. The granulomatous lesion causing the hour-glass constriction was provisionally regarded as either tuberculous or syphilitic.

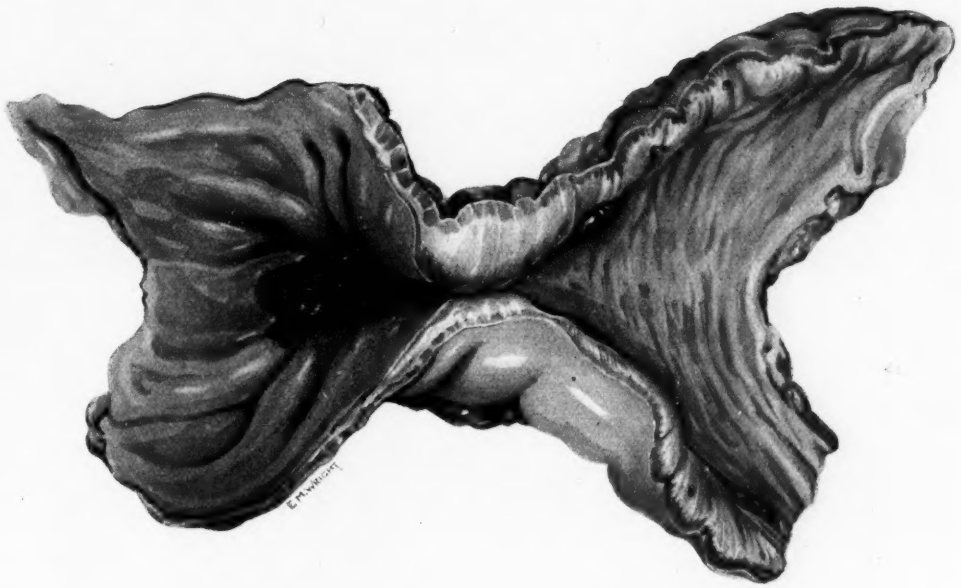


FIG. 233.—Stomach laid open along the greater curvature, showing the granulomatous and ulcerated lesion of the middle portion and the squamous-epithelial-lined upper loculus. Note the great fibrous thickening of the submucosa in this region. (× ⅓.)

HISTOLOGY.—

1. The granulomatous lesion in the centre of the organ presents the characters of hyperplastic tuberculosis. The lesion for the most part is devoid of tubercle follicles or giant cells, the ulcerated surface being clothed with a broad zone of highly vascular non-specific granulation tissue. Beneath this there is a greatly fibrosed and thickened submucosa which sends numerous strands of fibrous tissue into the underlying muscular coat. Here and there, however, both in the midst of the granulation tissue and deep in the fibrous zone, there are scattered, somewhat atypical, tubercle follicles, often perivascular in distribution, some with, some without, characteristic Langhans-type giant cells with peripherally arranged nuclei (*Fig.* 234). Tubercle bacilli have not been demonstrated in the follicles. A section of the ulcerated area extending along the lesser curvature of the lower loculus shows only very occasional ill-formed tubercle follicles. For the most part the lesion here consists of a narrow zone of non-specific, highly vascular, granulation tissue implanted directly upon the muscular coat (*Fig.* 235). The lower margin of the ulcer is undermined, the angle being occupied by a mixture of necrotic material and pus.

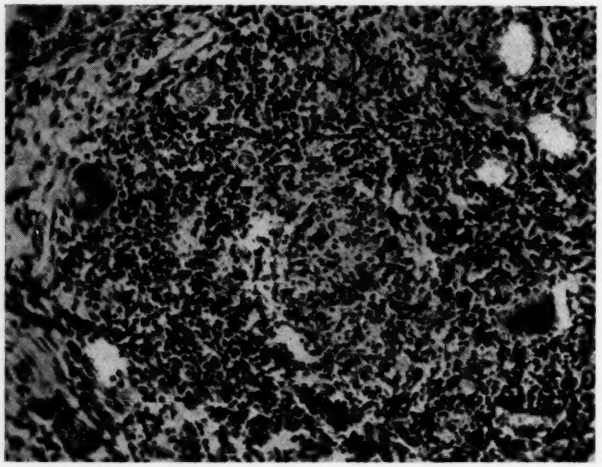


FIG. 234.—A tubercle follicle, with central area of epithelioid cells and marginal zone of lymphocytes in relation to which lie two giant cells of Langhans type.

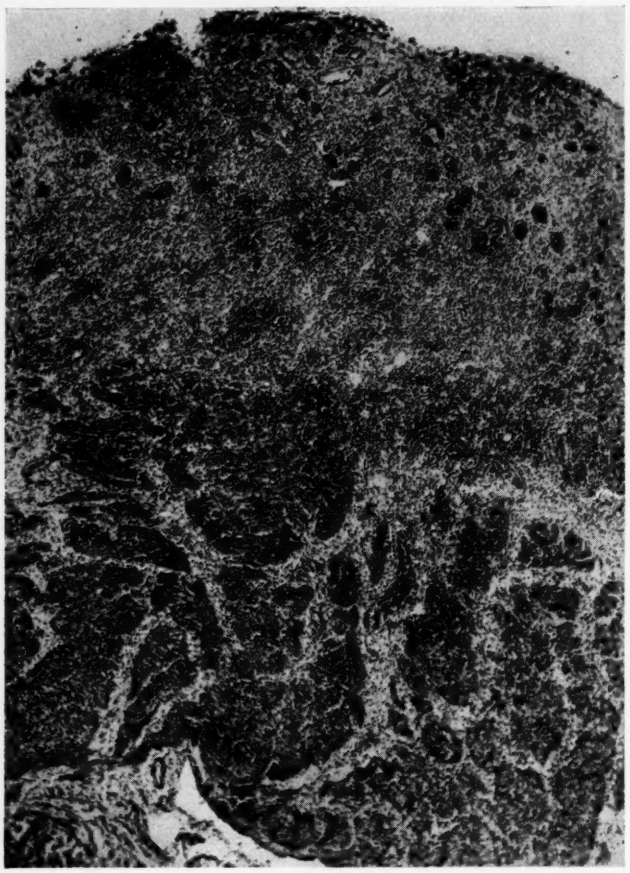


FIG. 235.—Floor of lower ulcerated portion of the mid-gastric lesion, showing (above) a thick layer of highly vascular, mainly non-specific, granulation tissue, and (below) the somewhat fibrosed muscular coat.

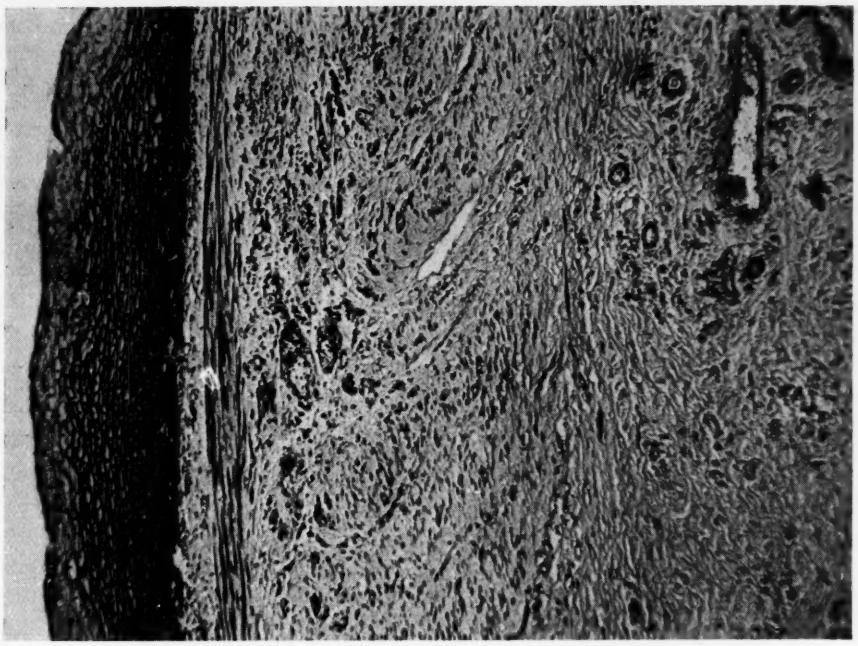


FIG. 237.—Another portion of the upper loculus, showing squamous epithelial lining with broad stratum lucidum. Submucosa thickened and fibrosed. The section does not extend as deep as the muscular coat.

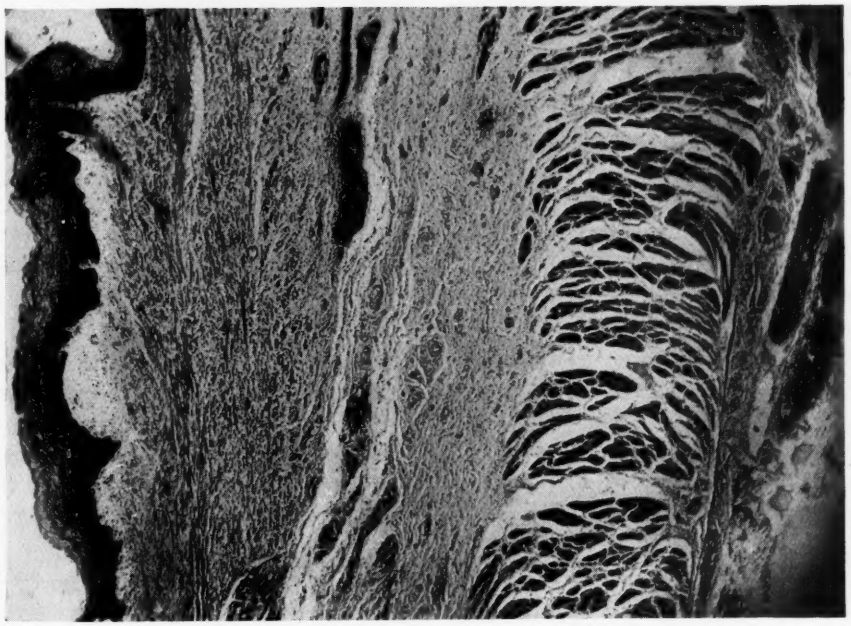


FIG. 236.—Section of upper loculus, showing squamous epithelial lining, hypertrophied muscularis mucosæ, thickened and fibrosed submucosa, and hypertrophied muscular coat.

2. Sections taken from various positions in the upper loculus show that it is everywhere lined by stratified squamous epithelium (*Figs.* 236–238). The epithelium is many layers thick and shows in places a well-marked stratum lucidum (*Figs.* 237, 238), but there is no actual keratinization. Nuclei are present even in the most superficial layers. In one place only (*Fig.* 238) in three blocks examined is there a group of mucus-secreting glands of gastric type devoid of oxyntic cells. Everywhere there is a very well-developed muscularis mucosæ, several times the normal thickness, with varying amounts of fibrous tissue lying amongst the unstriped-muscle bundles (*Figs.* 236, 237). The submucosa is much fibrosed and in places is as much as 5 mm. in thickness. Small aggregations of lymphocytes are present in the more superficial layers, but for the most part the submucosa consists of very densely collagenous, comparatively acellular, fibrous tissue.

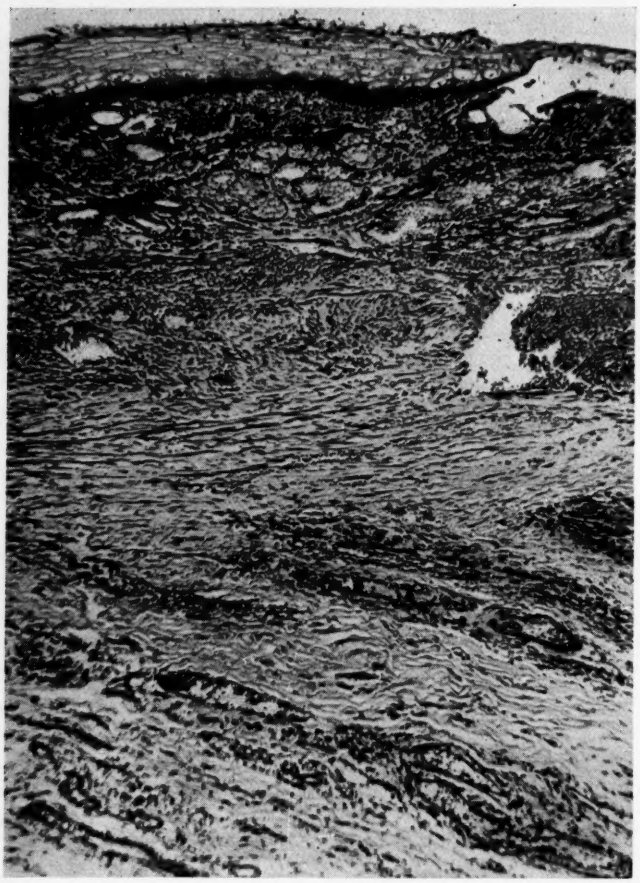


FIG. 238.—A third portion of the upper loculus, showing a few gastric glands lying beneath the squamous lining. The rest of the section shows only muscularis mucosæ and submucosa.

3. The muscular coat consists of two main layers, a broad inner and a narrow outer (*Fig.* 236), with well-developed Meissner's plexus between. The inner part of the inner coat is much broken up in places by strands of fibrous tissue, especially in relation to the granulomatous lesion, but also in the walls of both the upper and lower loculus. In the lower loculus, in the neighbourhood of the granulomatous lesion, the muscle bundles are separated by loose, œdematous, and highly vascular tissue with many inflammatory cells.

4. The mucosa of the lower loculus is thick and well developed, with a thick muscularis mucosæ much overrun by lymphocytes and plasma cells. There is a certain amount of chronic gastritic change, with excess of lymphoid tissue in the mucosa.

COMMENTARY

Pathological.—This case presents a number of interesting and unusual features :—

1. Hour-glass stomach is nearly always due to cicatricial contraction in the floor of a large chronic peptic ulcer lying astride the lesser curvature. Occasionally a sclerosing carcinoma of slow evolution may produce a somewhat similar type of deformity. In the present instance the lesion is granulomatous, having the characters, in our opinion, of hyperplastic tuberculosis.

2. Tuberculosis of the stomach in any form is generally regarded as rare. From time to time the routine histological investigation of this organ reveals the presence of miliary tubercles in the mucosa or submucosa, often in association with other lesions, peptic or neoplastic (Collinson and Stewart, 1927–28). Tuberculous ulcers, when they occur, are usually part of a widespread ulcerative process throughout the digestive tube, and, like the miliary lesion, are of little clinical interest or importance. Occasionally, however, they are due to tuberculous glands or peritoneal nodules ulcerating through the gastric wall. Hyperplastic tuberculosis is the rarest form of all. As in the corresponding ileo-cæcal lesion, it takes the form of a circumscribed tumour-like mass which tends to encircle the gut, and, as its chief site of occurrence is the pyloric portion of the organ, it leads presently to obstructive phenomena which are likely to be attributed to neoplasm. If, as is usual, a palpable tumour is present in the epigastrium, or if a test-meal shows achlorhydria, the diagnosis of gastric carcinoma can hardly fail to be made. The occurrence of a similar type of lesion in the mid-gastric region appears to be excessively rare. There is no mention of it in Konjetzny's article on hyperplastic tuberculosis of the stomach in Henke and Lubarsch's *Handbuch* (1928), nor can we trace another case of the kind in the literature.

The exact histological diagnosis in the present case has proved difficult. For the most part the lesion is non-specific, while presenting a widely different picture from that of ordinary peptic ulceration. There are, however, a number of follicular structures with Langhans-type giant cells, which we are prepared to accept as tubercle follicles even in the absence of demonstrable acid-fast bacilli. They are scattered throughout the more cellular part of the lesion, often in close proximity to small blood-vessels, though themselves avascular. This difficulty in firmly establishing the histological diagnosis of tuberculosis is well recognized in the hyperplastic lesion of the ileo-cæcum, where a number of blocks may have to be cut before a typical tuberculous field presents itself. Nor is it necessary that tubercle bacilli should be demonstrated before a reasonably probable diagnosis is ventured. By analogy with the intestinal disease, as well as with the published cases of hyperplastic tuberculosis of the pylorus, the lesion in this case is probably primary.

The possibility of the lesion being syphilitic was considered and rejected. There was no history of syphilis and none of the stigmata of that disease ; the Wassermann reaction was negative, and the histological characters were not at all suggestive.

3. Not the least interesting feature of this case is the fact that the whole of the upper loculus, except a narrow, bright-red zone of surviving mucosa along the lesser curvature, is completely lined by squamous epithelium. Accompanying

histological changes are great hypertrophy of the muscularis mucosæ, which is everywhere present beneath the epithelium, and dense fibrous thickening of the submucous coat. The squamous differentiation stops short at the stage of stratum lucidum. Whether this is a genuine metaplasia due to the changed environment resulting from the mid-gastric obstruction, or whether it has arisen by squamous epithelial replacement extending down from the œsophagus, it is perhaps idle to speculate. The condition simulates closely the normal state of affairs in the stomach of rodents and some other animals, and might reasonably be designated 'rattisation' of the stomach.

Clinical.—The chief interest centres in the diagnosis and in the possibility of cure by surgical removal. It would seem that a clinical diagnosis of carcinoma can hardly be avoided in these cases. Even at operation it may well be impossible to go beyond this. As bearing on the possibility of complete eradication, it may be mentioned that a large proportion of reported cases of hyperplastic tuberculosis of the pylorus has been regarded as primary. Of twenty-four cases of tumour-like tubercle of the stomach collected from the literature by Leriche and Mouriquand (1909), two only presented evidence of a clinically demonstrable lesion in some other organ. This is in accordance with the known facts of hyperplastic tuberculosis of the ileo-cæcal region.

In the present case, complete eradication of the disease by the operation of total gastrectomy would seem to have been effected. Both the immediate result and the after-history (during nine months) have been wholly satisfactory.

We are indebted to Dr. H. B. Scargill for the X-ray photographs.

BIBLIOGRAPHY

COLLINSON, H., and STEWART, M. J., *Brit. Jour. Surg.*, 1927–28, xv, 626.
KONJETZNY, G. E., in Henke and Lubarsch's *Handbuch der speziellen pathologischen Anatomie und Histologie*, 1928, vol. iv/2, 1048. Berlin.
LERICHE, R., and MOURIQUAND, E., *Rev. de Chir.*, 1909, xxxix, 520.

HALLUX VALGUS: A COMPARISON OF THE RESULTS OF TWO OPERATIONS

By ERIC I. LLOYD
ORTHOPÆDIC SURGEON, ROYAL NORTHERN HOSPITAL, LONDON

THE respective merits of the two principal operations for hallux valgus have been argued for many years. Surgeons are still divided and are inclined to put forward their own personal impressions unendorsed by the patient.

In order to get new light on the question I determined some years ago to perform the two operations upon examples of bilateral hallux valgus, and these have now been under observation long enough to justify some conclusions. It has throughout been my intention that the final pronouncement should be made by the patient and not by the surgeon, since the patient is a much better judge of his pain (and its relief) than the most sympathetic observer. It ought, moreover, to be especially easy to get an opinion on the relative comfort of two operated toes in the same patient.

An experiment such as this would be unjustified at the hands of anyone who believed in the sole efficacy of one operation. Past experience had shown that excision of the metatarsal head gave excellent results in the majority of patients and after a sufficient time. This opinion was supported by Perkin's analysis of the results of the operation on more than 50 patients.[1] Nevertheless, I was assured by surgeons whose opinion I respected that excision of the base of the proximal phalanx was a much better operation, and from a casual perusal of recent literature it seemed that this view was gaining ground,[2] though evidence to support it was entirely lacking.

OPERATIVE PROCEDURES

The following procedure was adopted. Examples of hallux valgus needing a bilateral operation were dealt with differently on the two sides by standardized operations.

1. Excision of Head of First Metatarsal (*Fig.* 239).—A tourniquet was applied and a curved incision with its base downwards was made over the inner aspect of the first metatarso-phalangeal joint. A circular area of bursa and capsule the size of a threepenny bit was then removed and the joint exposed and cleared above and below. The head and neck of the metatarsal were removed by an osteotome, and the shaft was trimmed with bone forceps and smoothed with a file after removing all loose fragments of bone. The skin was closed with sutures and the toe held in a corrected position by a zinc-gelatine (' viscopaste ') bandage.

2. Excision of Base of First Phalanx and Removal of Metatarsal Exostosis (*Figs.* 240, 241).—A tourniquet was applied and a dorsal incision made over the metatarso-phalangeal joint, which was then exposed on its dorsal, inner, and outer aspects. The base of the first phalanx, together with a small part of its

shaft, was then removed with an osteotome or bone forceps. The exostosis on the inner aspect of the first metatarsal was next removed with an osteotome, and the roughened parts of both bones smoothed with a file after extracting all loose fragments of bone. The articular and weight-bearing surfaces of the metatarsal were not damaged except in so far as removal of the exostosis encroached upon them. The skin was closed and the toe held in a corrected position by a zinc-gelatine (' viscopaste ') bandage.

FIG. 239.—Left hallux valgus. Operation for excision of head of first metatarsal. The head of the bone has been removed, and is shown separately. The extensor hallucis longus tendon and the sesamoid bones are seen.

After-treatment was the same for both toes. The bandage was cut off after ten days and the stitches removed. A fresh ' viscopaste ' bandage was applied for another week or ten days, and the patient encouraged to begin walking in a loose shoe or felt slipper. In most instances the shoes were wedged one quarter of an inch on the *outer* border in order to encourage weight-bearing on the affected part of the foot and to diminish any tendency to secondary metatarsalgia.[3]

Although many operations have been advocated for hallux valgus these are the two in common use. The description given is merely that of the ordinary procedure with no special additions except the use of a ' viscopaste ' bandage. The sesamoid bones are not removed in either operation and are in fact left severely alone.

COMPARISON OF RESULTS

At the close of the period of observation, which has varied between one and three years, the patient was asked for a report. It was made clear that inquiry was solely directed to comfort, and each patient was asked to indicate whether the toes were equally comfortable or to state which one was the better. The results are set out in *Table I*, and furnish, as far as I am aware, the first attempt to compare the result of two different operations on the same patient. It may be again stated that the verdict is the patient's, and refers solely to the relief of pain one to three years after the operations.

FIG. 240.—Right hallux valgus Excision of base of first phalanx and removal of metatarsal exostosis (Stage 1). The base of the phalanx has been removed, and is shown separately. The exostosis on the inner surface of the metatarsal has not yet been removed.

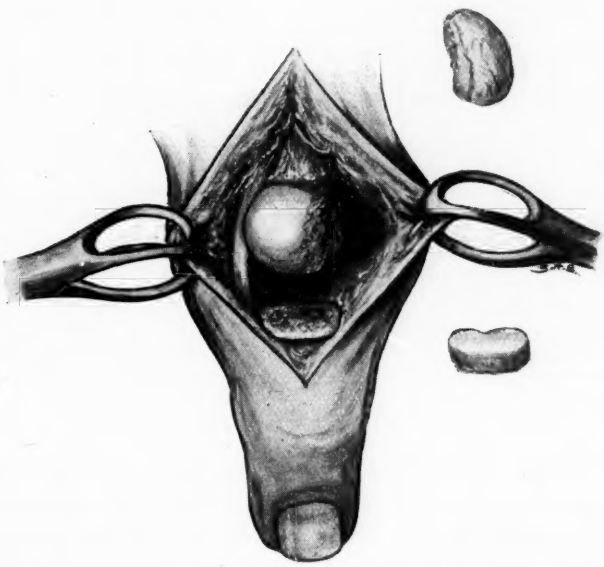


FIG. 241.—Right hallux valgus. Excision of base of first phalanx and removal of metatarsal exostosis (Stage 2). The exostosis on the inner surface of the metatarsal has now been removed, and is shown separately in the upper part of the figure.

Table I.—Comparison of Operative Methods in Twenty Cases of Bilateral Hallux Valgus on Basis of Patients' Findings

Case No.	Initials	Sex	Age	Period of Observation since Operation	Prefers Side on which Metatarsal Head Excised	Prefers Side on which Base of Phalanx Excised	Finds no Difference Between Two Sides
1	G. H.	F.	20	2½ yr.			×
2	A. D.	F.	46	2¾ yr.	×		
3	B. R.	F.	34	2½ yr.			×
4	D. G.	F.	45	2½ yr.			×
5	A. E.	M.	59	3 yr.			×
6	R. D.	F.	18	3 yr.			×
7	P. S.	M.	19	Nearly 2½ yr.			×
8	F. C.	F.	42	3 yr.			×
9	N. R.	F.	21	2½ yr.	×		
10	P. W.	F.	24	2½ yr.		×	
11	A. C.	F.	67	2 yr.			×
12	C. S.	F.	44	2 yr.		×	
13	R. W.	F.	24	2 yr.			×
14	D. S.	F.	25	1¾ yr.			×
15	R. M.	F.	32	1¾ yr.		×	
16	M. M.	F.	49	1½ yr.		×	
17	L. G.	F.	28	1½ yr.			×
18	L. P.	F.	52	1½ yr.		×	
19	M. D.	F.	34	1 yr.	×		
20	V. M.	F.	25	1 yr.	×		
				Total ..	4 (20%)	5 (25%)	11 (55%)

DISCUSSION

The series, though small, represents the verdict of twenty patients on forty operations, and gains some value from its uniformity of technique.

If one toe was more painful than the other it was not necessarily treated by the same operation. The metatarsal head was excised eight times on the right side and twelve times on the left. Metatarsalgia sometimes exists before operation, and Perkins[1] has rightly insisted that it is not relieved by operating on a coexisting hallux valgus. I would go further and add " even when the hallux valgus was the original cause of the metatarsalgia ". It is equally true that some patients induce

metatarsalgia after operation by persistent refusal to bear weight on the inner border of the foot. They may thus spoil the functional result of a successful operation and even select the wrong toe as being the more comfortable by erroneously attributing the metatarsalgia to the operation. I believe that this may have occurred in my series, but it is impossible at this stage to make allowance for it. It probably has not affected the majority, since it is noteworthy that more than half the patients report both toes equally comfortable from one to three years after operation.

SUMMARY

Twenty patients suffering from bilateral hallux valgus were subjected to different operations on the two sides. On one side the metatarsal head was excised, and on the other the base of the phalanx and the metatarsal exostosis.

From one to three years elapsed after the operations, and the patients were then asked to choose between the two toes purely from the point of comfort. The results are set out in a table, and seem to indicate that there is nothing to choose between the two operations as a means of relieving the pain of hallux valgus.

REFERENCES

[1] PERKINS, G., 'Removal of the Metatarsal Head for Hallux Valgus and Hallux Rigidus', *Lancet*, 1927, I, 540.
[2] LAKE, C., *The Foot*, 1935, 188. London: Baillière, Tindall & Cox.
[3] BANKART, A. S. B., *Manipulative Surgery*, 1932, 56, 57. London: Constable & Co.

PSEUDOTUBERCULOMA SILICOTICUM

By K. C. EDEN and J. HERBERT-BURNS
UNIVERSITY COLLEGE HOSPITAL, LONDON

THE reaction of the body tissues to the implantation of foreign bodies has been extensively investigated. Unabsorbable ligatures have been shown to produce endothelial and giant-cell reaction with fibrosis. The effect on the lungs of inspired irritating particles such as coal, asbestos, and silica dusts is of great importance in industrial diseases. It is seldom, however, that the implantation of undetected foreign particles forms a tumour which presents itself as a clinical and pathological problem. S. G. Shattock (1916–17)[1] published such a case, and gave the name of pseudotuberculoma silicoticum to the condition in view of the close resemblance of the tuberculous granuloma to the tissue reaction to buried particles of silica in a wound. J. S. Faulds (1935)[2] published two further examples of the condition. In all three cases the foreign particles were demonstrated in sections by means of the polarizer.

The following additional case came under our observation in the Casualty Department of University College Hospital.

A girl of 22 years complained of a tender nodule underlying an old scar on the left forearm. The nodule had developed slowly during the previous three months. The scar was the result of a fall sixteen years previously while walking along a flinty road. The district has much sandstone in it, and after a rainstorm a deposit of sand can be seen on the road. She complained that the nodule was painful on resting her arm on the elbow or on knocking it against anything.

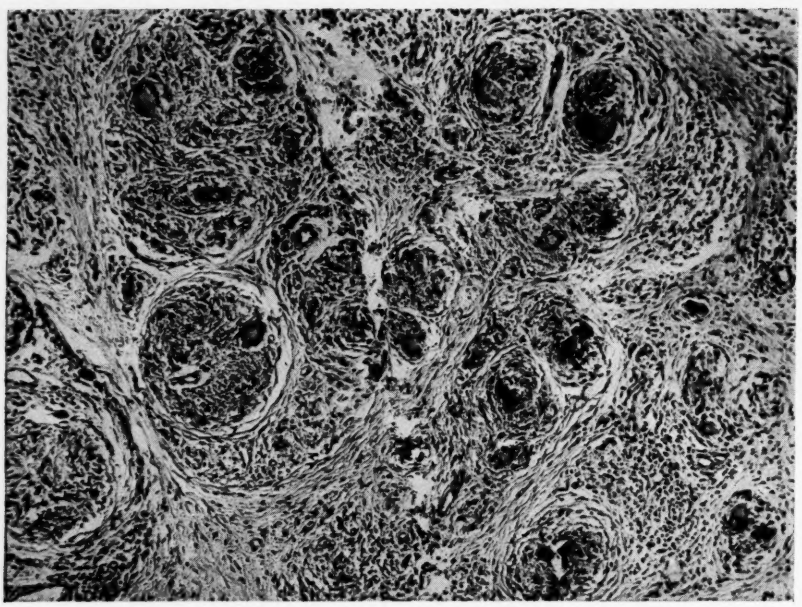


FIG. 242.—General low-power view (⅛ in.) of a piece of a section showing multiple giant-cell systems and a tear in the section. (× 78.)

Examination revealed a scar ¾ in. long and ⅜ in. wide, lying transversely across the back of the forearm 2 in. distal to the tip of the olecranon. Underneath the scar was a tender nodule the size of a hazel-nut, firm and slightly fluctuant, and attached to the scar and the deep fascia. The diagnosis of implantation dermoid was made, and it was proposed to excise the scar together with the cyst and to leave a longitudinal linear scar.

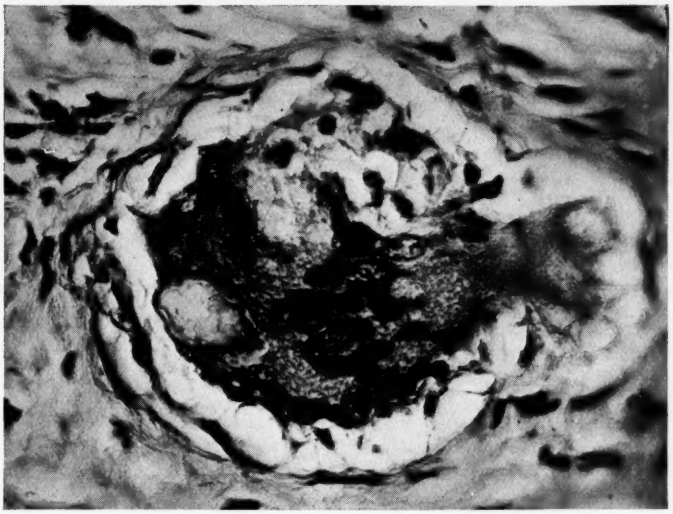


FIG. 243.—High-power view (1/12 in., oil immersion) of a giant cell with embedded silica particle. (× 500.)

FIG. 244.—High-power view (1/9 in., oil immersion) of a giant cell with embedded silica particle. (× 360.)

FIG. 245.—The same giant cell as in *Fig.* 244, showing the crystal under the polarizer. (× 360.)

At operation a small bursa was found superficial to the nodule, which was fibrous and densely adherent to the capsule of the elbow-joint, from which it had to be dissected.

Serial sections at 50-μ intervals were cut through the nodule, which proved to be extremely hard and gritty and took several chips out of the edge of the razor. The sections were torn and ragged, but no foreign particles were observed with the naked eye. The

microscopic appearance was almost exactly that of a tuberculoma. Clumps of large irregular giant cells, many with peripheral rings of nuclei, were scattered throughout the field, surrounded by epithelioid cells and lymphocytes and fibrous trabeculæ (*Fig.* 242). There was no sign of caseation in any of the sections. Ziehl-Neelsen staining revealed no tubercle bacilli. On carefully searching through the sections with the high-power lens, several crystalline particles were observed, some embedded in the fibrous tissue, others actually within the giant cells (*Figs.* 243, 244). The sections were therefore examined with polarized light and the particles were mostly found to be doubly refractile (*Fig.* 245). Unfortunately there was insufficient material left for chemical analysis. The wound healed by primary intention, and three weeks later there was no evidence of recurrence and the scar was not tender. A radiogram of the forearm at this time showed no foreign bodies.

COMMENTARY

In the four cases which have been reported, three have given a definite history of trauma, and in the fourth a particle of mineral, later identified as Welsh slate, was found in the centre of the tumour, conclusive evidence of some previous accident. Ours was, however, the only one in which a scar was obvious clinically. The time of onset of symptoms is interesting in view of the long period of apparent quiescence between the infliction of the injury and the appearance of the lump. In Shattock's case the interval was eleven years, in one of Faulds' it was ten years, and in ours sixteen years. Faulds attempted to explain this in his case by a second trivial accident three months before the onset of symptoms, which he suggested may have driven some of the particles through their fibrous capsules and so reactivated the cellular proliferation. In two of the cases the nodule was situated on the forearm, and in two on the face, the parts normally uncovered and exposed to injury. In the three cases in which an accident was remembered, it occurred on the road, an obvious source of silica.

The clinical appearance of a nodule underlying the skin of the exposed parts and associated with previous trauma simulates that of an implantation dermoid. In two of the cases this diagnosis was actually made. The nodules, however, appeared solid in all except our case, in which the fluctuation obtained was shown to be produced by an adventitious bursa. In addition, it was definitely tender in two cases, an uncommon finding in implantation dermoids. These points taken in conjunction with the history of a road accident many years previously are useful in the differential diagnosis, and make it advisable to bear the condition in mind and to take a radiogram of the part. Further proof of the condition is afforded by the detection of foreign particles with the naked eye, and in the tearing of the sections and the chipping of the razor during cutting, which was present in one of Faulds' cases as well as in ours.

The microscopic appearance closely simulates that of a tuberculoma. If tubercle bacilli can be demonstrated by Ziehl-Neelsen staining, it is of course valuable evidence against the diagnosis of pseudotuberculoma, but a negative finding proves nothing. In our case many of the giant cells had ringed nuclei, and it was impossible to exclude tubercle by the ordinary histological methods. The complete absence of caseation, however, was significant, and this was also seconded in the previous cases. In Shattock's case and in ours suspicious-looking particles were observed embedded in the giant cells and fibrous tissue, and on careful focusing it was possible to make out their crystalline nature. It is probable that the multiple groups of giant-cell systems correspond to individual particles of embedded silica.

The final evidence is afforded by means of polarization, and the particles were readily picked out in all the cases. Faulds in his article pointed out numerous sources of error in this method, and showed how collagen fibres, keratinized epithelium, striate muscle, and erythrocytes were all capable under certain conditions of refracting polarized light. In one of Faulds' cases a sufficiently large particle was obtained for chemical analysis, and the evidence of the presence of silica was therefore quite conclusive in this case.

It is evident that, although clinically this condition may simulate an implantation dermoid and pathologically a tuberculoma, when the evidence is taken as a whole the clinical history and pathological findings are typical and conclusive.

SUMMARY

1. Reference is made to three previously recorded cases of pseudotuberculoma silicoticum, and a fourth is described.

2. The clinical features of the condition are the history of a fall on a road and the development of a solid tender nodule at the site of injury many years later. The differential diagnosis from implantation dermoid is made.

3. Pathologically the condition is characterized by a fibrous gritty tumour, closely resembling a tuberculoma microscopically, but without caseation. Crystals of silica can be picked out with the high-power lens and polarized light, and silica may be found on chemical analysis.

We are indebted to Dr. G. R. Cameron for his advice and co-operation.

REFERENCES

[1] SHATTOCK, S. G., *Proc. Roy. Soc. Med.* (Pathol. Sect.), 1916–17, x, 6.
[2] FAULDS, J. S., *Jour. Pathol. and Bacteriol.*, 1935, xli, 129.

EMBOLECTOMY ON THE VESSELS OF THE EXTREMITIES*

By EINAR KEY, Stockholm

One of the most satisfactory operations that can be performed is the removal of an embolus by means of arteriotomy (embolectomy) in suitable cases. This has been made possible through the development of the technique of operations on the vessels of the human body.

HISTORICAL REVIEW

The first to try to remove an embolus by arteriotomy was Ssabanejew (1895). Because of threatened gangrene in one leg as a result of embolism he tried to remove the embolus from the femoral artery, but was not successful. During the first decade of this century, several surgeons tried in vain to remove an embolus or an arterial thrombus by arteriotomy in order to restore the circulation and prevent development of gangrene. Among the first to attempt this, the names of Moynihan, Francis Stewart, Sampson Handley, and Gordon-Watson must be mentioned. Also I wish to call to mind the interesting case operated upon by Murphy in 1908.

Trendelenburg hit upon the daring and ingenious idea of operating upon the pulmonary artery to remove large emboli producing fatal symptoms. In experiments on calves he produced artificial pulmonary emboli by introducing long pieces of organic tissue into the jugular vein and then succeeded in removing these by pulmonary arteriotomy. In 1907 Trendelenburg first tried to remove a pulmonary embolus from a patient. The case was that of a woman, 70 years of age, with sudden collapse due to a pulmonary embolus. He was successful in removing the embolus, but the patient died of hæmorrhage. Several surgeons then attempted to do Trendelenburg's operation for threatening pulmonary embolism, but it was a long time before a good result was attained, and doubt began to be cast upon the practical significance of the operation. Justifiable attention was therefore awakened when at the German Surgical Congress in 1924 Kirschner reported a case he had been able to save by means of Trendelenburg's operation. This fortunate experience led to renewed interest in the operation, and successfully operated cases have since been reported by Meyer, Giertz, Crafoord, and Nyström. However, it would seem to be only exceptional cases where this operation can save patients with severe symptoms of pulmonary embolism.

Embolectomy is of greater importance for the removal of emboli producing dangerous circulatory disturbances in the extremities. Even here, however, it was a long time before good results were attained. In 1911, at a meeting of the Société de Chirurgie de Paris, Lejars stated that there existed little hope that the removal of an embolus would actually do away with the obstruction it had produced and

* A lecture recently delivered at the London Post-graduate School of Medicine.

that a new thrombus would not develop. Shortly after, in the same year, Labey performed the first successful operation for embolus. It was situated in the common femoral artery and there were symptoms of impending gangrene. The operation was done six hours after the embolism developed. The second such case with a successful outcome was operated upon by me shortly after. This was also an instance of embolism of the femoral artery operated upon six hours after the onset of symptoms.

More and more cases have come to operation. At the Maria Hospital in Stockholm we have devoted the greatest interest to this operation. From 1912 to 1934, 382 embolectomies have been performed in Sweden on cases where the emboli have given rise to grave circulatory disturbances in the extremities. At the Maria Hospital, and in my private practice to date, 48 embolectomies have been performed on 43 patients (there was an embolus in both legs in 5 cases). I myself have done 32 embolectomies on 30 cases.

ETIOLOGY

A thrombus in the heart is the commonest source of an embolus giving rise to dangerous circulatory disturbances in the extremities. More rarely the origin is from a thrombus in the wall of the aorta. The cause of thrombus formation in the heart with subsequent embolism in the above-mentioned sites is usually a decompensated mitral valvular lesion, and occasionally myocarditis. Sometimes these emboli develop following an infectious disease, while others appear shortly after an operation on a patient who has never had any symptoms of cardiac failure. In these instances also the source of the embolus is probably a cardiac thrombus. In rare cases paradoxical embolus may occur.

Women seem to have emboli in the extremities oftener than men.

In the age group 31–40 there is a great increase in the frequency, and most of the cases are between 31 and 70 years of age.

LOCALIZATION

An embolus will lodge most readily where a vessel divides. In the greater number of cases that have come for operation the embolus has been located at the division of certain large vessels, such as the aortic bifurcation, parts of the iliac vessels, the femoral artery, the popliteal artery, and the axillary where the scapular artery branches off.

The localization of the embolus in the 382 Swedish cases (collected by Nyström) can be seen in *Table I.*

Thus, most of the emboli operated upon were situated in the lower extremities, and then most often in the common femoral,* with the second greatest frequency in the common iliac. In some cases the embolus which was the cause of the operation had been preceded by other emboli in a site which did not demand surgical interference. After the operation, fresh emboli have sometimes appeared. *It is important to realize that not infrequently two or more emboli requiring operation*

* Throughout this paper the term common femoral artery is used to refer to the portion of the femoral artery between the external iliac and the origin of the deep femoral; from here to the popliteal artery it is regarded as the superficial femoral artery.

may appear at different sites. They may be situated either in the main artery of the same extremity or in another.

Table I.—Localization of Embolus in 382 Operated Swedish Cases

Artery	Number	Frequency
		per cent
Axillary / Brachial	45	11·8
Ulnar	1	0·3
Bifurcation of aorta ..	17	4·5
Iliac	66	17·3
Femoral	208	54·5
Popliteal	43	11·3
Tibial	2	0·5
Total ..	382	100

SECONDARY THROMBOSIS AND GANGRENE

An embolus not removed generally in time goes through a stage of secondary thrombus formation. As a result, an embolus which at first did not fully block the lumen may become an obstruction. The embolus increases in size most easily and for the most part towards the periphery, but it may also extend in a centripetal direction. The secondary *thrombosis impedes the collateral circulation,* and in this way the danger of gangrene is increased. The danger of gangrene is therefore greater with embolism than in the case of ligature of the vessel at the corresponding site. The following table provides some figures on the percentage frequency of gangrene following ligature of certain vessels.

Table II.—Frequency of Gangrene after Arterial Ligature

Site	Wolff, 1908	Heidrich, 1921	Makins, 1922
	per cent	per cent	per cent
Upper extremities ..	7·8	5·9	—
Lower extremities ..	20·4	20	—
Subclavian artery	4·8	9·7	—
Axillary artery	15	9·8	—
Brachial artery	4	3·13	—
Aorta	—	100	—
Common iliac artery ..	50	100	—
External iliac artery ..	11·2	13·4	16·6
Common femoral artery ..	25	21·8	25·9
Superficial femoral artery	12·7	10·4	14·1
Popliteal artery	14·9	37·2	32·5

This table shows that there is more danger of gangrene in ligature of the great vessels of the leg than of the arm. Experience teaches that when an embolus is located at the branching of the above-mentioned arteries there is more or less pronounced danger of gangrene in the extremities. Experience has also shown that

with an embolus at the aortic bifurcation, in the common iliac artery, the common femoral, and the popliteal, there is more danger of gangrene than with an embolus in the axillary artery and in the upper portion of the brachial.

The time of the appearance and spread of secondary thrombosis varies considerably. The danger generally increases with the time elapsing after the embolus appears, yet the increase of the risk is not in direct proportion to the length of time. I have seen secondary thrombosis beginning within two hours after the appearance of an embolus. Sometimes, however, in a case of late operation there has been no thrombosis. In a case operated upon by Ipsen there was no secondary thrombosis after eleven days. However, in one of Sundberg's cases a thrombus no less than 86 cm. in length had formed within twelve hours. A secondary thrombus renders the operation more difficult and the prognosis more unfavourable.

In cases which come early for treatment, it is generally easy to distinguish at operation between the original embolus and the secondary thrombus formation; in late cases this may be difficult or impossible. In some cases it may also be difficult or impossible to determine where the primary embolus was located.

SYMPTOMS

The symptoms may set in either suddenly, which is most usual, or slowly. In the former case, the embolus is so large that it causes serious disturbance of the circulation. In the latter case it at first obstructs only a part of the lumen. Later, by secondary thrombus formation, or by the appearance of a new embolus, the lumen may become blocked, and the symptoms consequently increase. The degree of circulatory disturbance caused by the presence of an embolus depends upon several factors: (1) whether it fully obstructs, (2) the development of the collateral circulation, (3) the secondary thrombus formation, (4) the condition of the walls of the vessels, and (5) the action of the heart. Consequently the intensity and extent of the circulatory disturbance vary between quite mild cases without any danger of gangrene and threatening gangrene of varying extent.

The symptoms characterizing an embolus are partly subjective and partly objective. *The subjective symptoms* are pain, a sensation of cold, and disturbances of sensibility. *The objective symptoms* are change in colour of the skin, a lowering of skin temperature, disturbed motility, absence of skin- and tendon-reflexes, and absence of pulsation.

The pain most often sets in suddenly, and this is highly significant. At the same time, the patient experiences a sensation of cold and numbness in the extremity affected. The sensory disturbances vary from partial to complete suspension of sensory function. The boundary of complete suspension is not often sharply defined, but the transition to partial suspension may be clearly observed.

The suspension of circulation results in marked anæmia of the affected extremities, the temperature falls, and the skin becomes deadly pale or possibly somewhat cyanotic. Discoloration may be seen in livid to dark blue patches. As one would expect, the anæmia and low temperature are most pronounced towards the periphery. A prick from a needle causes no bleeding. The motility is suspended or restricted in proportion to the degree of circulatory disturbance.

The sensory disturbances, the change in the colour of the skin, and the cool part of the extremity do not always fall quite within the same boundary, neither

do they always quite correspond to those areas where the motility has been affected. Apparently motility at least may remain for some time in a part of the extremity which is cold and in which sensory functions are suspended or impaired.

There is usually no pulse below an embolus. One can sometimes palpate an embolus like a string in the painful area. The possibility of palpating an embolus depends upon its situation and on the corpulence of the patient.

As the collaterals take over a part of the circulation, the limits of the region threatened with gangrene will be situated at a longer or shorter distance peripheral to the embolus, and they are not at first very sharply defined. The extent of the region threatened with gangrene varies in different cases, as has been said, according to the development of the collaterals, the size of the embolus, the heart action, the condition of the vessel walls, and also the stage reached by the secondary thrombosis. Likewise, the symptoms of circulatory disturbance may diminish or disappear should an embolus in a suitable position become again detached and lodge more peripherally. If, from being not quite obstructive, an embolus becomes so through secondary thrombus formation or through blocking the collaterals, the symptoms naturally increase.

Some cases have precursory symptoms probably depending upon a small embolus. In other cases, pronounced symptoms in another area have preceded an embolus. It would take too long to go into the symptomatology of emboli in various locations.

DIAGNOSIS

The symptoms of an obstructing embolus that appears suddenly in a large vessel of the extremities are so marked (sudden severe pain in the extremity, a feeling of cold and numbness, sensory and motor disturbance, and disturbance of the circulation) that the diagnosis is seldom difficult. When the embolus is not entirely obstructive to begin with, but becomes so gradually by augmentation, the symptoms are often not so pronounced at first, and the diagnosis may be difficult.

Differential Diagnosis.—

Thrombus due to Arteritis.—It is of the utmost importance to distinguish between an embolus and an arterial thrombus due to arteritis. Indicative of embolism are sudden onset of the symptoms in a patient with organic disease of the heart or with an active predisposition to thrombus formation as a result of an infectious illness or an operation. The origin of an embolus, however, cannot always be pointed out. Often these patients have had, or have, circulatory decompensation. When the symptoms do not set in so quickly the differential diagnosis is more difficult. In the case of an arterial thrombus the patient has often had premonitory symptoms for a long time, even for years—sensations of cold and numbness, neuralgia or rheumatic pains in the extremity, and circulatory disturbance in the peripheral parts of the limb. Furthermore, one must of course take into consideration the presence of arteriosclerosis. It is true that the evidence of arteriosclerosis is not decisive and does not preclude embolism.

Developing Thrombus.—Mistakes have been made between a developing thrombus and an embolus. With a thrombus in the vein, the extremity is warm, cyanotic, and swollen. As a rule the pulse is perceptible and the sensibility unchanged, and usually the thrombosing vein feels distressingly tender. With an embolus,

the extremity is cold, generally pale, sensibility is partially or completely suspended, and the pulse is imperceptible or very weak. The thrombosing vessel can sometimes be palpated. When a thrombus precedes an embolus, the latter may be easily overlooked.

Local Traumatic Arterial Thrombosis.—After trauma with a slight internal injury, without the wall of the vessel being ruptured, an arterial thrombus may appear in the injured place. As a rule, the differential diagnosis in such a case can be made from the history.

To Localize an Embolus.—As already shown, owing to the collaterals, the circulatory disturbance will appear peripherally and only at a greater or less distance from the embolus. In many cases, therefore, the conclusion has been reached that the embolus was seated still more peripherally. By taking into consideration the fact that an embolus generally lodges at the division of an artery, and that it is seated more or less central to the boundary of the circulatory disturbance, and also by carefully observing where the pulse ceases in the artery in question, one can generally succeed in localizing it. When taking the pulse, one must take into consideration that a difficulty in feeling it may be owing to the patient's weak heart action.

SOME POINTS AFFECTING THE OUTLOOK

Injury to the Intima with Consequent Thrombus Formation.—In the area where an embolus is situated, a lesion of the intima is likely to develop sooner or later, and, after the embolus has been removed, may cause thrombus formation. The vessel may become obstructed, and the result of removing the embolus come to nothing. There is no doubt that it is difficult, if not impossible, to decide in a given case whether a thrombus which has arisen after the removal of an embolus was caused by a lesion of the intima or by some mistake in technique. Even though the risk of the lesion with its consequent tendency to thrombus formation increases with the length of time from the occurrence of the embolism, yet the increase of the risk is not in direct proportion to the length of time; wide variations and strange exceptions are to be found just as in secondary thrombus formation.

Relation of Length of Time of Obstruction to Tissue Vitality.—Naturally of great interest and practical importance is the question *how long the blood-stream through the main arteries to an extremity can be suspended by an embolus without injury to the vitality of the tissue.* As yet it is not known with exactitude how long the blood-stream to an extremity can be obstructed without loss of vitality in the area supplied. It is general knowledge that, if one must bandage an extremity to stop hæmorrhage, for example with an Esmarch, one must not leave it in place too long, or ischæmic contraction or even gangrene will appear. It is stated that ischæmic contraction may arise when the bandaging has lasted from two to three hours. In the case of an embolus, the conditions are quite different. Here the arterial circulation is eventually suspended while the vein and lymph channels are not obstructed. Nor are the nerves exposed to pressure. Furthermore, the embolus may happen not to be fully obturating, until it becomes so by a secondary growth, so that the time when the symptoms set in, and the time of complete suspension of the flow of blood through the arteries, do not

coincide. In the case of an embolus, the collateral channels also play more or less of a part, and the heart action and condition of the vessel walls are of considerable importance. The patient's general condition and the vitality of the tissues likewise play their part.

After the removal of the chief embolus, small emboli that have previously lodged further out in the peripheral arteries may interfere with the circulation. Secondary thrombosis may obstruct important collateral channels. After the removal of the embolus, if the secondary thrombus has not also been completely taken away, more or less circulatory disturbance will be caused. There are thus many factors contributing to the result. No set time before gangrene occurs can be given; one must be prepared for great individual differences. Twenty-four hours was the longest time that has passed between the appearance of the symptoms and embolectomy, without ischæmic necrosis or gangrene setting in. Probably the circulation was not completely obstructed so long as that.

EMBOLECTOMY

Anæsthesia.—In all my cases I have used local anæsthesia with novocain and adrenaline, which gave a complete and satisfactory anæsthesia. As these operations have to do with individuals of low physical tone, and mostly with irregular heart action, it is most important that the operation be carried out as carefully as possible. The risk in operation is, no doubt, considerably less if it can be done with a local anæsthetic. When operating on the relatively easily accessible vessels, such as the lower part of the axillary, brachial, external iliac, femoral, and popliteal arteries, one generally ought to manage with local anæsthesia. In removing an embolus in the aorta, or in the common iliac artery, if one must do a laparotomy, it will as a rule be necessary to use a narcotic.

Technique of Operation.—When performing embolectomy, it is of highest importance that the right technique be used. The slightest mistake may cause thrombosis and thus the good result of the operation may be lost.

As the technique for the suturing of vessels is nowadays well known, I shall not give an account of it. I myself have largely used Carrel's technique, with very fine needles and very fine silk sterilized in vaseline. In my first cases, I covered the wound with vaseline compresses. In this procedure the rubber gloves used during the operation become very slippery, which makes the sewing with fine needles considerably more difficult. I have therefore made a slight change in the technique. As sodium citrate prevents the blood from clotting, I have replaced the vaseline compresses with compresses dipped in 2 per cent sodium citrate. The arteries have been surrounded with the same, and the surface of the wound covered with it. From the time when the vessel is opened until the completion of suturing, instruments and gloves are rinsed in 2 per cent sodium citrate solution. The curettes or probes that are used for removing the embolus should be smeared with vaseline.

When the artery is laid bare, the operator satisfies himself as to the position of the embolus and its extension proximally and peripherally. If, as is usually the case, the embolus has lodged at the division of an artery, he carefully attempts to isolate the vessel where it divides so that flexible artery clamps may be put upon these also. Should other branches of the artery lead from the area in which the

embolus is situated, the most prudent method is to isolate these vessels as well, in so far as vessel clamps or rubber tube can be used. When the artery has been surrounded with compresses dipped in sodium citrate solution, a weak vessel clamp is placed central to the embolus. Instead of pinching the artery by a soft vessel clamp I have produced a stoppage by making a kink in the vessel by pulling on a thin rubber tube which has been drawn around the vessel.

When the arteriotomy has taken place the embolus may happen to fall out of itself or by a slight pressure on the vessel. Generally it must be lifted out, and this should be done exceedingly cautiously, with a fine forceps or a small blunt curette, in order that the intima may not be injured. At times the embolus is so fragile that it goes to pieces when taken hold of and has to be removed in many parts. When the embolus is long, or a secondary thrombus is present, it may sometimes be difficult, or impossible, to clear entirely the vessel. It is of utmost importance that this be done as completely as possible. Should one not succeed in removing the secondary thrombus, and this is of such length that it cannot be extracted otherwise, one may use a blunt instrument through an arteriotomy opening below and attempt to loosen the embolus and let the flow of blood wash away the pieces of the thrombus. Of course all instruments intended to be used in the vessels must be carefully covered with vaseline.

When the localization of an obstructing embolus is unfavourable from the point of view of surgical access, as in the aorta, the upper part of the axillary artery, and common iliac artery, it has been tried to move the embolus to the nearest easily accessible place with the aid of blunt instruments introduced in the artery through an arteriotomy. In this case the incision in the artery is made below the embolus in the nearest convenient place. The embolus is loosened with a blunt instrument introduced through the arteriotomy, letting the flow of blood wash away the embolus to the place of the incision. When doing this the artery must be closed by a clamp or rubber tube just below the arteriotomy, so that pieces of the thrombus may not flush into the peripheral parts of the vessel. The pieces are squeezed out through the incision in the artery or are lifted out.

The distal part of the external iliac artery can easily be exposed extraperitoneally under a local anæsthetic. The proximal part will be more difficult, particularly with stout persons. The common iliac artery and the aortic bifurcation are exposed most easily by laparotomy. Bauer was the first to remove with success an embolus in the aortic bifurcation by this method. Few other such cases, where the embolus was removed successfully by laparotomy, have been reported. Usadel preferred to perform a direct embolectomy after having exposed the aorta and the common iliac artery retroperitoneally by a large incision. A direct embolectomy through a laparotomy or large retroperitoneal exposure, which must usually be performed with a general anæsthetic, is nevertheless a great strain on these patients, who are mostly of poor physical tone.

It is far less trying for them if one loosens the embolus with a blunt instrument introduced through an incision in the femoral artery, letting the flow of blood rinse it out. That an embolus in the aortic bifurcation can be advantageously removed in this way has been shown in one of my own cases. In an operation after this method upon an embolus situated where the aorta divides, the other side of the common femoral artery also ought to be exposed first and a vessel

clamp placed there, so that the pieces of the embolus which are loosened and possibly forced out to this side may be stopped by the vessel clamp and easily taken out afterwards. In order to attempt the removal of an embolus from the aortic bifurcation by means of retrograde probing, it would often be necessary to do this from both sides. Nyström has tried in a case of bilateral embolism of the iliac arteries and in cases of embolism of the aortic bifurcation to bring the emboli down to incisions in the femoral arteries beneath the inguinal ligament by a kind of milking applied directly to the artery. An incision was made along the inguinal ligament and the hand was introduced in the retroperitoneal space, making its way closely along the large vessels to the sacral promontory. By pressure with the fingers the embolus was felt to burst, and it was possible to dislodge it down the vessels and by an incision in the femoral artery to remove the masses.

After the embolus and possibly secondary peripheral thrombi are removed, vessel clamps also should be placed so that the bleeding of the collaterals may not impede the sewing-up of the wound in the vessel wall. These clamps should be placed peripherally to the arteriotomy opening, and on the vessels that lead from the opening; that is to say, between the part of the main artery where the central and the peripheral vessel clamps have already been placed. As a secondary thrombosis may rise proximally to an embolus, one should take off the proximal clamps for a moment or two before sewing the vessel wall together. Thus any centrally placed thrombus, or remains of the embolus, can be flushed out by the stream of blood. During this flushing-out process, the peripheral vessel-clamps must be in place, so that any possible parts of the embolus or the central thrombus may not flush into the peripheral parts of the vessel.

When the embolus has been removed, the blood should be allowed to spurt out through the arteriotomy opening in a vigorous stream with intermittent jerks synchronizing with the pulse. Should the blood flow without pulsation, we have an indication that the passage is not quite clear, and that there is some obstacle above. This obstacle must then be cleared away, either by retrograde probing, or by laying the vessel bare higher up and making a fresh arteriotomy. Thrombi left in the peripheral arteries will cause more or less severe circulatory disturbance according to their extent.

As already stated, embolism is often recurrent, and two or more emboli frequently appear in the main artery in the same extremity. During the operation it is therefore most important to direct special attention to the possibility of manifold emboli within the chief artery. If such be overlooked, the circulation will not be fully restored, and gangrene may set in. After the embolus and the contingent secondary thrombus are removed and the vessel has been sewn together, investigation must be made as to whether the circulation has been completely restored in the extremity. Should this not be the case, an examination must be made to discover whether more emboli are present, and if so these must be removed if possible.

Arteriosclerotic changes of the wall highly endanger the result of embolectomy. The intima, which is altered by the arteriosclerotic changes, is further hurt by arteriotomy, and new thrombi can be formed which soon stop the passage. Arteriosclerosis does not exclude a good result of embolectomy. In an 82-years-old woman Torell has done embolectomy on the femoral artery with good result.

RESULTS

Up to now we have at the Maria Hospital and in my private practice operated 48 times on 43 patients (in some cases several embolisms occurred). Naturally I consider the result fully satisfactory only when the patient remains alive and the circulation is completely restored. Several of the patients, however, succumbed to their serious illnesses, though in many of the cases we succeeded in restoring the circulation. The results are tabulated in *Table III.*

Table III.—RESULTS IN 48 EMBOLECTOMIES

SITE	NUMBER OF OPERATIONS	RESULT OF OPERATION					
		Good	Death shortly after Operation		Death within a Month		Gangrene
			Good Circulation	Circulation not Improved	Good Circulation	Gangrene	
Axillary and brachial arteries	4	4	–	–	–	–	–
Bifurcation of the aorta..	2	1	1	–	–	–	–
Common iliac and external iliac arteries ..	10	1	1	–	1	4	3
Femoral artery	24	9	1	2	3	5	4
Popliteal artery	7	3	–	–	–	1	3
Posterior tibial artery ..	1	1	–	–	–	–	–
Totals	48	19	3	2	4	10	10
Percentage ..	100	39·5	6·2	4·2	8·3	20·8	20·8

In the column of *Table III* labelled 'good' are inserted those cases in which the circulation is restored, where the extremity is saved from gangrene, and where the patient is alive. Those patients operated upon for embolus often succumb to uncompensated heart disease though the circulation in the extremity in question is restored by the embolectomy. In deciding the value and estimating the results of embolectomy these cases must be taken into account. If the patient dies shortly after the operation the judgement of the result naturally will be difficult or impossible. The circulation may be restored, but if the patient had been alive longer, perhaps a secondary thrombus would have arisen at the site of the operation, which would have again stopped the artery. If the patient is alive longer and the circulation in the operated extremity is restored and functions well, then the embolectomy so far has succeeded, even if the patient succumbs to his serious malady. I have therefore collected in different columns of the table the cases which have died shortly after the operation (within twelve hours) and those which have died between twelve hours and one month after. In the first of these columns I have separated those cases where the circulation was improved from those where the circulation was not improved after the operation. In the other group (those who died between twelve hours and one month after operation) the cases have been divided with respect to (1) those in which the circulation was permanently restored by the operation, and (2) those in which disturbed circulation and gangrene occurred after the operation. In the last column those cases are gathered which

were alive more than one month after the operation and in which gangrene had occurred. In the greater number of these cases an amputation was done.

The results in the 382 Swedish cases collected by Nyström are shown in *Table IV*.

Table IV.—Results of Embolectomy in 382 Swedish Cases

Site	Discharged Surviving		Died in Hospital	Total
	With Restored Circulation	After Amputation		
Axillary artery } Brachial artery } ..	20 (=44·4%)	9 (=20%)	16 (=35·5%)	45
Ulnar artery	—	—	1	1
Aortic bifurcation ..	3 (=17·7%)	—	14 (=82·3%)	17
Iliac artery	10 (=15·1%)	13 (=19·7%)	43 (=65·2%)	66
Femoral artery ..	43 (=20·7%)	32 (=15·4%)	133 (=63·9%)	208
Popliteal artery ..	9 (=20·9%)	14 (=32·6%)	20 (=46·5%)	43
Tibial artery	1	1	—	2
Total	86 (=22·5%)	69 (=18·1%)	227 (=59·4%)	382

The result of embolectomy on the axillary and brachial arteries is better than on the great vessels of the lower extremities. It seems to me that this can be explained on the basis of better collateral paths in the arm. The danger in ligature of the axillary and brachial arteries is considerably less than after ligation of the femoral or popliteal artery. In obstruction to the circulation due to thrombosis after embolectomy it is therefore probable that it is the collateral circulation which saves the upper extremity oftener than the lower. In cases of circulatory disturbance threatening the condition of the lower extremities, the best results have been obtained in the embolectomies on the femoral artery, the next best on the popliteal, slightly less good on the iliac, and worst on the aortic bifurcation.

The prognosis as to the possibility of preventing by embolectomy the development of gangrene in connection with an embolus depends very largely upon how soon the operation takes place after the appearance of the embolus. The importance of early operation appears in my material: 34 operations have been performed within ten hours after the onset of the symptoms; out of these, 19 (55·8 per cent) have regained normal circulation. Out of the 32 cases which were operated upon at the clinic in Upsala, 50 per cent were sent home with restored circulation.

AFTER-RESULTS

In most cases, embolectomy has been performed on patients with some degree of organic heart disease. These patients may go through the operation, yet the cause of the trouble still remains, and they generally succumb to it sooner or later. Nevertheless, many have had relatively good health for a number of years, and could do more or less work. Naturally the prospect of a lasting benefit is better in the cases where there has been no previous organic heart disease but the embolus is due to some other cause, such as infection.

Strömbeck has followed up 61 cases which up to 1933 were reported from Swedish hospitals surviving after embolectomy and with restored circulation. He

found that out of these about three-quarters still are alive 1 year after the operation, half of them 3 years, a third 5 years, and an eighth 10 years. Hindmarsh and Sandberg have followed up the patients from the Maria Hospital who were sent home with restored circulation. Though after two to three years most of the patients are still alive, two-thirds of them died within 10 years. Two patients were alive more than 15 years after the operation. In some cases the patient has had some troubles: certain stiffness of the peripheral joints (fingers and toes), sensations of numbness, coldness, or tiredness, and occasionally pains after exertion. These symptoms indicate that the circulation has not been fully restored, and might in some cases depend upon small embolisms in the peripheral vessels.

SPASMOPHILIC DRUGS

An embolus often produces a spasm in the part of the wall of the vessel where it lodges and thus disturbs the circulation still further. For this reason Peiser has suggested the use of a spasmolytic substance which would do away with the vascular cramp and improve the circulation. Thus intravenous injections of Eupaverin have been tried. Denk has recently reported the use of this treatment on 5 of his own cases of emboli in the extremities and 20 others from the literature, as well as 9 cases of pulmonary emboli. The result must be regarded as remarkable, for in the former group 17 were cured, 3 improved, and 5 unimproved, while in the latter group 7 survived and 2 died. It would seem to be too early to give a final judgement on this method of treatment, but the results are remarkably good. In my opinion one should not neglect its use; but even if such intravenous injections can improve the circulation when an embolus is producing grave circulatory disturbance in one of the extremities, I consider that the embolus should be removed; otherwise one may be forced to do this later, when the prospect of a good result is much poorer. We shall indeed have gained a great deal if this method decreases the mortality from large massive embolism in the pulmonary artery.

CONCLUSION

An embolus which causes circulatory disturbance of a threatening character in the upper or lower extremities ought to be removed by arteriotomy unless there are contra-indications present. Moreover, the operation ought to take place as soon as possible. The sites chiefly involved in such cases have already been mentioned.

As the embolus suitable for operation is far from rare, it is of importance that practising medical men should learn to diagnose it in time, and that they should immediately consult a surgeon or send the case to the surgical department of a hospital.

BILATERAL LOBECTOMY FOR BRONCHIECTASIS

By IVOR LEWIS
NORTH MIDDLESEX HOSPITAL, LONDON

THE removal of lungs or lobes of lung with any consistent success is so recent that the operative criteria have scarcely taken form, let alone finality. Most thoracic surgeons have been inclined to the view that in bronchiectasis the disease should be confined to a single lobe, which is usually a lower lobe, if surgical treatment is to be undertaken. Or, in the case of the right lung, the middle lobe also, if affected, might be removed with the lower. Still more recently a number of surgeons in different parts of the world have reported 17 cases of total pneumonectomy for infective disease involving the whole of a lung. Cases of bilateral bronchiectasis involving both lower lobes, however, have been considered to be definitely beyond the scope of surgery, and as far as the writer knows the only successful case of the kind that has been described is that of Eloesser. Alexander also refers to four cases of his where this procedure was proposed, but it is not quite clear how many survived. There is no record of any in this country. Previous attempts at bilateral lobectomy have usually not been carried to a successful issue because the patient is so ill after the first operation; this seems to make the opposite diseased side flare up in a remarkable way. It appears, therefore, that an account of a successful case might be of some interest in a field of surgery where both the principles and technique are in the formative stage.

The remarkable advances in the surgery of the lung during the last five or six years have been made possible only by the development of radiography to its present high pitch, and particularly the introduction of bronchography. A decade before, the introduction of opaque media had revolutionized the diagnosis of diseases of the alimentary canal; so, in the twenties, a similar development in the case of the respiratory tract added certainty and precision to the diagnosis of pulmonary disease. In each case there followed a remarkable sharpening of interest and extension in surgical treatment.

Regarding the alimentary tract, it is already being realized that enthusiasm sometimes, as in the case of peptic ulcer, rather outstripped judgement. It is possible that the same is now happening in the case of diseases of the lung. But it will be many years before it is possible to assess the ultimate value of lobectomy, let alone pneumonectomy.

SPECIAL CONSIDERATIONS

Radiography.—A careful lipiodol radiograph is an essential pre-requisite to any surgical treatment. The exact topography of the disease must be ascertained. In the bilateral case here recorded, the first bronchography showed that both lower lobes were affected. Subsequent bronchographies were then carried out at intervals of a week, doing one lung at a time so as to secure filling of the upper and middle

main bronchioles in particular. In this way it is possible to obtain complete and unconfusing pictures of right and left bronchial trees separately.

Vital Capacity.—The considerations which apply to the bilateral case differ in several respects from those applying to solitary lobectomy or even to total pneumonectomy. The cardinal fact in the latter is that the patient is in possession of at any rate one healthy lung. The success of the operation depends on the adequacy of that lung, not only during the operation, but during those anxious days following. Its serious involvement, as by aspiration broncho-pneumonia or contralateral pneumothorax, is likely to be fatal. The bilateral case has to rely for a time, after the first lobectomy, on a lung part of which is diseased. Moreover, during and after the second lobectomy the patient has to rely on the recovered upper lobe of the lung first operated on. Problems that arise are thus the vital capacity of the particular patient with (*a*) one lung, (*b*) one lobe, working, and also the very difficult problem of the most suitable anæsthetic.

Fortunately the adequacy of the vital capacity under conditions (*a*) and (*b*) can be determined with fair certainty pre-operatively from the patient's condition under preliminary pneumothorax. In the bilateral case, with this end in view, a pre-operative pneumothorax down to less than half the lung volume is probably an advantage.

Anæsthesia.—Much thought and ingenuity has been expended by anæsthetists and surgeons on the peculiar problems of anæsthesia for major thoracotomies. The progress from negative-pressure chamber to positive-pressure endotracheal anæsthesia, to closed mask, to spinal anæsthesia, has corresponded with the increased knowledge of the physiologist, and even more with the increased confidence as the result of experience of the surgeon. An endotracheal catheter by its trauma undoubtedly increases the liability to tracheobronchitis. Positive-pressure anæsthesia must tend to distribute pus and any particulate matter throughout the lungs. In unilateral disease the ingenious endobronchial catheters with inflatable cuffs may minimize this danger, but obviously cannot help in the bilateral case. Here the ideal seems to be a spinal anæsthetic.

The practice of inflating the remaining lobe by positive pressure when closing the chest seems to me to be not without danger, as this must force infected material to the terminal bronchioles or even infundibula. A much safer method to secure early expansion is to empty the pleural cavity of most of its air by means of the artificial pneumothorax apparatus before the patient leaves the operating table.

Whether bilateral lobectomy for bronchiectasis is a sound procedure from a pathological point of view must remain a matter for suspended judgement for the present, as for that matter must solitary lobectomy and pneumonectomy. Bronchiectasis is, of course, a progressive disease. Whether it is also a necessarily *spreading* disease is not clear. It is known that in the neighbourhood of an abscess of the lung the bronchioles after a time become bronchiectatic. It is therefore all too probable that healthy bronchioles adjacent to a bronchiectasis likewise gradually become involved by the disease. Arrest of the spread can probably be secured by the removal of the stagnant focus of infection.

The Stage of the Disease Suitable for Operation.—Here again the considerations are rather different from the unilobar case. Accepting the rough descriptive stages of dry, septic, and putrid bronchiectasis, it may be said that the first is too early and the last too late, as long as the operative hazards remain what

they are. In the second group there is probably a considerable number of bilateral cases that can be successfully treated by surgery. The main problem is to recognize them before they reach the putrid stage and become too toxic and emaciated. The most certain way would seem to be to regard patients, especially children, with chronic bronchitis, bronchiolitis, or recurrent attacks of bronchopneumonia, as probably bronchiectasis and to investigate the matter by bronchography. The suspicion is particularly likely to be confimed if there is clubbing of the fingers.

CASE REPORT

I. R., a tall, fair-haired girl of seventeen, was admitted to the North Middlesex Hospital on Dec. 2, 1935, suffering from an exacerbation of a chronic respiratory infection. She had a cough, pain in the chest, shortness of breath, a slight temperature, and copious yellow sputum, dullness of the left base, with bronchial breathing. This attack soon settled down to a chronic state of cough, expectoration 2 to 2½ oz. of pus daily—not offensive—and a temperature occasionally rising to 99° but with a pulse round about 90. She had moderate clubbing of the fingers. There were always extensive râles over both bases. Weight, 7 stone 2 lb. on admission.

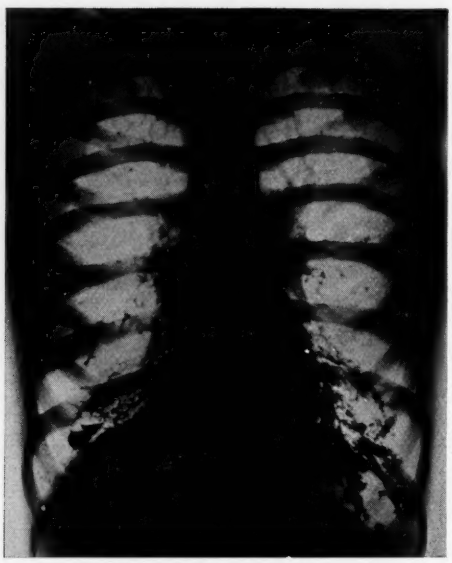


FIG. 246.—Bilateral bronchiectasis. Bronchograph taken December, 1935, before operation.

PREVIOUS HISTORY.—There was a chest illness at the age of 9 years, for which she was three months in another hospital. Since that time she had spent most of her life either in hospital, or in a convalescent home in the Isle of Wight "getting over the chest trouble".

INVESTIGATIONS.—Radiography of the chest showed some fibrosis at the bases. *Lipiodol* showed marked bronchiectasis of both lower lobes, cylindrical on both sides, but with saccular areas as well in the right base (*Fig.* 246). Both lungs were later done separately, and as far as could be judged the condition was confined to the lower lobes.

In the meantime steps were taken to improve the patient's condition. Postural drainage was secured on a Nelson bed, plenty of nourishing food was given, and daily actinotherapy. By the end of March she was much stronger and had put on a stone in weight. It was then thought that the maximum improvement had probably been obtained, and it was decided to attempt ablation of the lower lobes one at a time. She still brought up 2 to 3 oz. of pus a day. The left was clinically the worse side and so was done first.

Left artificial pneumothorax was carried out, 1400 c.c. of air being introduced within the ten days preceding operation. Extensive basal adhesions could be seen on the X-ray film.

FIRST OPERATION: LEFT LOWER LOBE. April 17, 1936.—Anæsthetic administered by Dr. John Challis—12·5 c.c. of spinal percaine supplemented with a little gas and oxygen with face-piece. During the spinal puncture and throughout the operation the patient was carefully kept on her 'good' side with the thoracic spine arched upwards and the head low. The anæsthesia on the operated side reached the clavicle, while the under side was little affected as judged by the respiration.

A left postero-lateral incision was made in the 6th intercostal space. A quarter of an inch of the 6th rib behind the angle was resected. Extensive pleural adhesions were present over the lower lobe, more especially to the diaphragm. These were slowly divided, mostly by blunt dissection. The pedicle was controlled by Roberts' tourniquet, and divided rather shorter than usual. The stump was swabbed with N.A.B. Forty-day No. 2 catgut was used for multiple mattress sutures to occlude vessels and bronchioles. The pleura was over-sutured, but not very completely. The chest was then closed: pericostal catguts; two layers of muscle catguts; skin—six s.w.g. and fine continuous silk. In the tenth intercostal space a tube was led to a water-seal drainage system. The operation lasted 1½ hours.

The condition of the patient after the operation was rather bad for about twelve hours. She was pale, with a pulse of 120 and of poor volume. After that she steadily improved. The tube had ceased draining by the third day. On the third morning the small remaining pneumothorax (500 c.c.) was withdrawn with artificial pneumothorax apparatus through the first intercostal space anteriorly. There was very slight surgical emphysema within three inches of the wound.

On the fourth and fifth day there was a transient increase of infection of the right lower lobe, with a small area of bronchial breathing and expectoration. The wound healed by first intention, and the tube track remained dry after the tube was removed on the 13th day.

May 7: Patient was getting up and walking at the end of three weeks and resuming actinotherapy and exercise. Expectoration is now reduced to 1½ oz. a day including postural drainage.

June 2: Patient now very fit, artificial pneumothorax on second side induced this day after two previous unsuccessful attempts due to extensive adhesions. Altogether 2000 c.c. air introduced in three amounts. Lung collapsed to about one-third. At the base, owing to extensive adhesions, moist sounds can still be heard, while the rest of the lung is silent.

SECOND OPERATION: RIGHT LOWER LOBE. June 11.—The anæsthetist again was Dr. John Challis—12 c.c. of percaine were introduced in the third lumbar space. At times during operation a little oxygen was given on a mask, more as a placebo than on account of any respiratory distress.

A long postero-lateral intercostal incision was made. Bleeding points were sealed with diathermy. Rib not resected; exposure quite good enough. Very extensive and thick adhesions were present over the whole lower lobe, also a wide one over middle of upper lobe. These were divided, the worst ones with diathermy. The phrenic adhesions were virtually continuous, and the lung had to be laboriously peeled off. A fair amount of bleeding took place from a vessel in the diaphragm, which was ligated with a suture. Ligamentum latum clamped and divided. Adhesions were even worse in the interlobar fissure, and it was only with the greatest difficulty that it could be identified and separated at all. Eventually it was separated without any apparent hole into the parenchyma. Roberts' tourniquet was applied to the pedicle, and two-way No. 2 catgut mattress sutures used. Pleural inversion followed with No. 1 catgut. N.A.B. was used on the raw pedicle. No positive-pressure inflation was used at the end. The chest wall was closed—airtight—with pericostal catguts and continuous suture for muscles; for the skin, continuous fine silk plus four s.w.g. was used. An intercostal tube was placed laterally through the tenth space. Before the patient left the table 2000 c.c. of air was aspirated from the pleura with artificial pneumothorax apparatus. The operation lasted 1 hour 20 minutes.

The patient's condition was remarkably good throughout. She was a little ashen but never cyanosed, and the pulse at the end of the operation was only 116 and of quite good volume.

June 13: Colour now quite pink. No distress. Radiograph shows almost full expansion. Breath-sounds coming through well. Other side: no adventitious sounds. Water-level oscillation ceased this morning (40 hours after operation) with the coming together of

the pleural surfaces. Only a small fluid opacity in costo-phrenic angle. Total drainage of bloody fluid since operation—one pint.

June 14: Upper lobe fills hemithorax. Some moist sounds under right breast, and patient is coughing up a few drachms of thin purulent sputum.

June 17: For last two days patient has had intense pain in abdomen and has been awake all night. She refuses to lie down as it makes pain worse. Maximum pain is one inch below umbilicus to the right. The intercostal tube was removed. (It was catheter size No. 16 and fitted very tightly.)

June 18: No pain at all since removal of tube. General condition has been excellent.

July 12: Recovery uneventful except for the intercostal nerve pain. There was never any real anxiety over her condition after the second lobectomy. There was a mild infection of the tube-track only (temperature never above 100°). She got up on the nineteenth day. The wound healed by first intention. There was no surgical emphysema on this occasion. Only 1 drachm expectoration now, and this is mucoid. No appreciable pus. Quite strong,

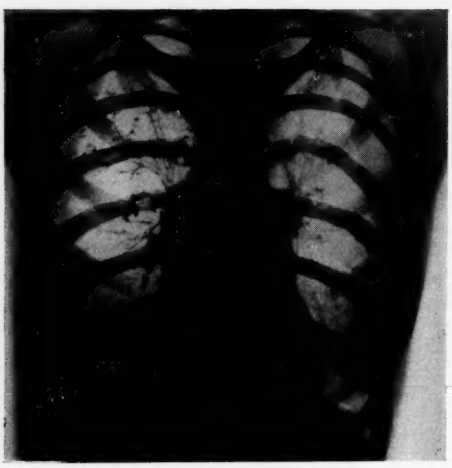


FIG. 247.—Bronchograph taken July, 1936, after bilateral lobectomy.

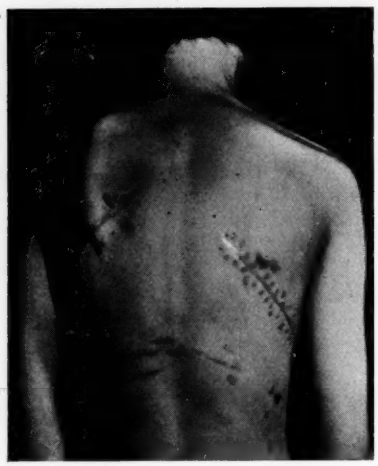


FIG. 248.—Showing position of scars after bilateral lobectomy.

and takes exercise in the grounds freely without any shortness of breath. Condition on radiography with lipiodol is shown in *Fig.* 247, and the position of the incisions in *Fig.* 248.

Sept. 5: For the last six weeks there has been no phlegm. She is now quite strong and is working as a ward maid.

PATHOLOGY.—Each of the removed lobes was greatly contracted and covered with a thickened pleura which had been adherent to the chest wall. The fresh specimens had lost the pink, aerated look of normal lung, and were of a dark fleshy appearance, although there were considerable surface areas still of normal colour. The texture was spongy in these parts, but elsewhere solid fibrous areas could be felt. The bronchioles were practically all dilated and stood out from the surrounding cut surface; pus could be squeezed from them. A few saccules of pus the size of currants were found, but mostly the bronchiectasis was cylindrical. The lung parenchyma was fibrotic around the bronchial tubes. There were also tracts of round-celled infiltration and fibrosis extending between neighbouring tubes. The mucous membrane was much thickened and the mucous glands hyperplastic.

SOME POINTS IN TECHNIQUE

The success of the operations was due, I think, to attention to the following points in the technique.

Great pains were taken to improve the patient's general state before the operation by postural drainage, good food, and actinotherapy. She gained a stone in weight.

As for surgical technique, there is little that is different from the unilateral case. The Brunn-Shenstone one-stage operation appears to be steadily gaining ground on the two-stage ' strangling ' operations. It commends itself as a cleaner surgical proposition, and the mortality of some of the best series, such as that of Tudor Edwards and Thomas, compares favourably with the best two-stage mortality, e.g., Alexander's. The reasons in favour of preliminary artificial pneumothorax are more cogent than even in the unilateral case.

In each lobe the pedicle was dealt with by the multiple mattress suture method described by Tudor Edwards. The pleural over-suture, while snug, had no pretence to being air-tight in either case, and the security of the pedicle seems to depend but little on this. No fistula occurred on either side. The rib above the incision was resected at the angle in the first lobectomy, but not in the second. In both cases the approach was entirely adequate, but in the second there was no surgical emphysema whatever of the chest wall, owing, no doubt, to the better apposition obtained with the rib intact. If air passes into the wound so may infection from the pedicle. I have on other occasions observed that better apposition of the wound can be obtained if no ribs are divided.

On both sides water-seal drainage through a low intercostal tube was employed. As usual the tube drained for only about forty-eight hours. A ' portable ' radiograph of the chest was taken daily for six days after each operation. The blood was grouped in readiness, but no transfusion was needed.

The thoracic wounds were covered merely by a strip of gauze held in place with short lengths of strapping. There is in this way no interference with respiratory movements after the operation. The patient was alternately sitting up and lying on one or other side, so as to lessen the chances of hypostatic pneumonia.

SUMMARY

1. In addition to the two cases previously described in the literature, a case of successful bilateral lobectomy for bronchiectasis is described.

2. The limited indications for such a procedure and the special considerations in technique and management are discussed.

3. It is suggested that in the bilateral case reasonably early diagnosis is specially important if surgery is to be of help, and all cases of chronic or recurrent affections of the lungs, particularly in adolescents, must be regarded as possible bronchiectases.

BIBLIOGRAPHY

ELOESSER, L., " Bilateral Lobectomy ", *Surg. Gynecol. and Obst.*, 1933, lvii, 247.

ALEXANDER, J., " Observations on Total Pulmonary Lobectomy and Pneumonectomy, " *Ann. of Surg.*, 1935, ci, 393.

EXPERIMENTAL SURGERY

NERVE GRAFTING

By F. H. BENTLEY* and MARGARET HILL
RESEARCH LABORATORIES, ROYAL COLLEGE OF SURGEONS OF ENGLAND

INTRODUCTION

It has been shown several times during the last twenty-five years, by experimental work in animals, that a nerve-graft will serve to bridge successfully a nerve gap, so that, in time, the anatomical and physiological continuity of the nerve is restored. When, however, at the time of the Great War, nerve-grafts were used to repair peripheral-nerve defects in man, the results were far from satisfactory. A full résumé of the literature up to 1934 is given by Stookey[1] and by Davis and Cleveland,[2] and need not be repeated here. The main feature which emerges from a perusal of this voluminous literature is the great diversity of opinion that exists on the value of a nerve-graft in peripheral-nerve surgery.

French surgeons[3, 4, 5] believe that a successful result can be obtained, and some have gone so far as to use grafts from cadavera and from animals, first storing the grafts in alcohol in order to kill the living cellular elements, and have claimed successful results with such grafts. The published case records, however, are brief, and are unsatisfactory inasmuch as late results are not given, and so many contradictory results are recorded that it is not possible to form an exact opinion on the value of their procedures.

English and American surgeons found their results were on the whole poor: Stopford[6] recorded 20 cases of autogenous nerve-grafts, in none of which was there evidence of recovery of function. Platt[7] expressed more or less the same opinion as a result of his experiences with 15 cases of nerve-graft plus fascial tubalization, and Platt and Bristow[8] in a comprehensive survey of the subject found the results so disappointing that they concluded: "The attitude of British surgeons towards the value of the nerve-graft continues to be one of scepticism."

The nerve-graft, therefore, remained condemned until the work of Duel and Ballance in 1931.[9, 10] These workers showed, first in monkeys and then in man, that recovery of function followed the implantation of a short nerve-graft into a defect in the petrous portion of the facial nerve. The protocols of their experiments, and the films and pictures of their results, show conclusively that under the conditions of their work, recovery of function followed the implantation of a nerve-graft.

Duel and Ballance, however, were led further by a study of the writings of Cajal. Cajal had accepted an observation of Tello,[11] that portions of fresh nerve implanted into the cerebral substance were absorbed, whilst pieces of degenerated nerve attracted the nerve-fibres of the brain. Tello's conclusion was that "the empty channels of the degenerated grafts are especially rich in neurotropic

* Mackenzie Mackinnon Research Fellow (Royal College of Physicians of London and Royal College of Surgeons of England).

substances, whereas in the normal nerve grafted directly, though not entirely absent, they are liberated very tardily". Cajal had an equal belief in the neurotropic attraction in a piece of degenerating nerve. He writes[12]: "The ideal (nerve) graft is the peripheral stump newly taken from an operated animal 8 to 15 days after the operation. The newly formed fibres travel through the empty sheaths with extraordinary speed, deviations and retrogressions being much diminished." Duel and Ballance, therefore, started to insert pieces of degenerated nerve as grafts, and claimed that in such cases recovery of function was obtained in a quarter to half the time taken following the use of fresh grafts.[13, 14, 15] This advantage of a degenerated graft over a fresh one was expressed in no uncertain terms, and Ballance gave three reasons for the advantage:—

1. The products of Wallerian degeneration within the degenerated graft exert a neurotropic attraction on the down-growing nerve-fibres (Cajal and Tello).

2. As the undisturbed peripheral end of a divided nerve has an intact blood-supply, the products of Wallerian degeneration are rapidly removed, leaving the neurilemmal tubes empty. If such a piece of nerve is used as a graft, these tubes are ready to receive new nerve-fibres immediately. Whereas a piece of fresh nerve used as a graft obtains a new blood-supply only slowly, the products of Wallerian degeneration are therefore not removed for some time, and form a barrier to the down-growth of the new fibres.

3. During the time taken for the vascularization of the fresh nerve-graft and the clearing of the neurilemmal tubes, the fresh graft is "a foreign body, which becomes surrounded in two weeks by young fibrous tissue which blocks the ends of the graft, thus forming a barrier to the immediate entrance of axis cylinders: much time is required before the axons are able to pierce this cork of young fibrous tissue, whereas the axis cylinders can and do enter at once the freshened ends of a degenerated graft".

It should be noted that there are three conditions implied in this argument:—

1. That the products of Wallerian degeneration do exert a neurotropic attraction on new-growing nerve-fibres.

2. That the old neurilemmal tubes do persist and allow new nerve-fibres to traverse them, and that the presence of the lipoidal masses—products of Wallerian degeneration—form a barrier to the down-growth of these fibres.

3. That the fresh nerve-graft provokes a foreign-body reaction whilst the degenerated nerve-graft does not.

EXPERIMENTS

In collaboration with Sir Charles Ballance, experiments were begun at the Royal College of Surgeons eighteen months ago, to investigate more fully the use and principle of the degenerated nerve-graft, and to try to determine the reason for the poor results of nerve-grafting in peripheral-nerve lesions in man.

METHODS

1. Nerve-suture Experiments.—These experiments were carried out to determine whether the rate of recovery of function was influenced in any way by the state of degeneration in the peripheral-nerve segment.

The external popliteal nerve of the cat was used throughout the investigation, since the resulting paralysis troubles the cat little and there is no tendency to

trophic ulceration. Under ether anæsthesia the nerve was exposed in the right thigh, and divided at the level of the upper border of the gastrocnemius. Nine to twenty-one days later the nerve-ends were re-exposed, freshened, and sutured. At this second operation the external popliteal nerve of the left leg was divided at the same level and immediately sutured. Fine silk on a fine atraumatic needle was employed for suture material and great care was taken to obtain accurate end-to-end approximation of the nerve, and to pass the sutures, two at each suture line, through the nerve-sheath only. A certain number of days after this operation, under chloralose anæsthesia, the nerves were exposed on each side proximal to the suture lines and stimulated electrically. The presence or absence of movements of the exposed peronei and extensor longus digitorum tendons as a result of this stimulation was noted, and the cat then killed.

To avoid aberrant results from spread of current we have not used the faradic coil as the source of stimulation, but the discharge from a condenser of small capacity. The condensers used have been from 0·002 to 0·006 microfarads, charged with a 2-volt battery, and the charge, therefore, thrown into the nerve is so very small that aberrant results from spread of current are eliminated.

2. Nerve-graft Experiments.—

a. AUTO-GRAFT.—The external popliteal nerve of the cat was again employed as the subject of the experiments, but at a higher level in the thigh than in the nerve-suture experiments in order to obtain a more circular compact piece of nerve than the rather flattened ribbon available below. The graft was taken, under ether anæsthesia, from the external popliteal nerve in the thigh, and implanted in a corresponding defect in the upper third of the external popliteal nerve of the other leg. In some experiments a piece of normal (fresh) nerve was used as a graft; in other experiments the donor external popliteal nerve was first divided and allowed to degenerate in situ, and grafts of different numbers of days' degeneration were used. The site of implantation of the graft was kept as constant as possible, as well as the length of the graft—3 cm., which represents about one quarter of the total length of the external popliteal nerve in the thigh. We placed great importance on the technique and accuracy of suturing and on exact correspondence between the size of the cut end of the graft and of the recipient nerve.

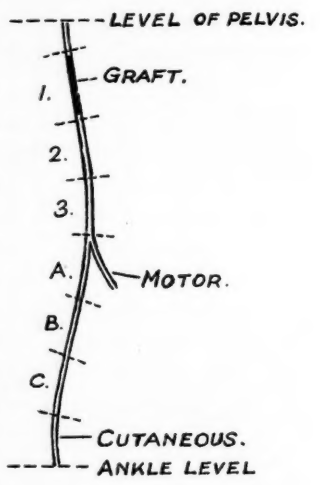


FIG. 249.—Diagram of nerve segments.

A certain number of days after operation, under chloralose anæsthesia, the nerve was exposed proximal to the graft and stimulated electrically as in the nerve-suture experiments. Presence or absence of movements of the exposed tendons of the peronei and extensor longus digitorum as a result of stimulation was noted; the whole length of the nerve was then excised from above the graft down to the level of the ankle, and the cat killed. The length of nerve was pinned out on cork, and fixed in one piece in ammonia-alcohol.

When fixation was complete, the nerve was taken and divided into segments as follows: The site of origin of the motor branch was the fixed point from which

measurements were made: from this point lengths of nerve 3·5 cm. in length were cut off (*Fig.* 249). These segments of nerve were stained by Ranson's silver impregnation method, and serially sectioned. In this way we had a record of the extent of regeneration along the main trunk of the nerve and its long sensory branch, and a measurement of the distance of the graft from the motor branch—an important point in making comparisons of times of recovery of motor function.

b. HOMEO-GRAFT.—The procedure was the same as in the autogenous nerve-graft experiments, except that the graft was taken from one cat and implanted into a second one. The procedure differed also from the auto-graft experiments in that both external popliteal nerves were grafted, a fresh graft being implanted into the left nerve and a degenerated graft into the right.

RESULTS

1. Nerve-suture Experiments.—In each animal two parallel experiments had been carried out. On the one side (the right) the nerve had been divided and sutured only after a period of degeneration varying from nine to nineteen days. On the other side the nerve had been divided and sutured immediately.

Table I shows the result of the full series of this experiment. It will be seen that 42 or more days after operation (*Cats* 1–7) motor function was equally present on the two sides; that after 35 days (*Cat* 8) motor recovery had occurred on both sides, although on the right—previously degenerated—side both extensor longus digitorum and the peronei contracted, while on the left contraction of the extensor only was observed; and that 28 days or less after operation (*Cats* 9–11) recovery of motor function had not occurred on either side.

Table I.—RESULTS OF NERVE-SUTURE EXPERIMENTS

No. of Cat	Number of Days' Degeneration of Right Nerve before Suture	Number of Days between Nerve-suture Operations and Subsequent Exposure and Stimulation	Movements of Extensor and Peronei Tendons on Nerve Stimulation	
			Right Side (preliminary degeneration)	Left Side (immediate suture)
1	9	112	+	+
2	11	103	+	+
3	13	89	complete absence of regeneration	+
4	9	76	+	+
5	14	62	+	+
6	10	53	+	+
7	15	42	+	+
8	13	35	+	+ *
9	14	28	−	−
10	12	22	−	−
11	19	15	−	−

* Only extensor longus digitorum. No peronei response.

The difference between the regenerative processes on the two sides was therefore very slight, and not sufficient to suggest any effective increase in neurotropic attraction in the previously degenerated nerve. One would not therefore expect any difference in neurotropic attraction between a fresh and a degenerated nerve-graft, unless the onset of Wallerian degeneration is delayed in an isolated piece of

nerve (fresh graft) or the products of this degeneration in the isolated nerve differ in some way from those in a nerve degenerating in situ. We have evidence, however, to show that Wallerian degeneration is in thirteen days as advanced in the one as in the other.

Experiment.—The right external popliteal nerve of a cat was divided high up in the thigh, taking care not to strip the nerve from its bed. At the same operation 3 cm. of the left external popliteal nerve in the thigh was excised and laid in an intermuscular plane. Thirteen days later a portion of the degenerated nerve from the right side and the isolated piece of nerve from the left side were removed, fixed, and stained by Ranson's method, and sectioned. In the piece of nerve degenerated in situ and in the isolated piece of nerve, Wallerian degeneration had reached an advanced stage (*Figs.* 250, 251). In both, the axis cylinders were fragmented and the thickened neurilemmal tubes filled with lipoidal masses. The

FIG. 250.—Longitudinal section of peripheral end of nerve divided in situ, after 13 days. Note extent of Wallerian degeneration, and compare with *Fig.* 251. (× 135.)

FIG. 251.—Longitudinal section of isolated piece of nerve, after 13 days. Note extent of Wallerian degeneration, and compare with *Fig.* 250. (× 135.)

appearances in the two are quite comparable except that absorption of the products of Wallerian degeneration is more advanced in the piece of nerve degenerated in situ (and therefore with an intact blood-supply) than in the isolated piece of nerve. Vascularization of the isolated piece of nerve, however, has begun, and capillaries have already penetrated into the outer parts of the nerve, so that absorption of the products of Wallerian degeneration is occurring in those parts. It does not appear, therefore, that after 13 days the state of Wallerian degeneration differs very much in an isolated piece of nerve and in a nerve degenerated in situ.

We have concluded from these experiments that preliminary degeneration does not in itself facilitate subsequent axonal growth, and that any advantage from possible neurotropic attraction in the degenerated graft can be disregarded. It should be mentioned here that there is in addition evidence from the work of

Weiss[16] that neurotropic attraction plays no part in the growth of nerve axons, and that the factors responsible for directing growing axons along a nerve are physical and not chemical.

If, then, any superiority of the degenerated graft exists, it must depend on the two other factors described by Duel and Ballance—namely, the blocking of the fresh nerve-graft by unabsorbed products of Wallerian degeneration or by the connective-tissue reaction that the fresh graft provokes.

2. Nerve-graft Experiments.—

a. AUTO-GRAFT.—Fresh nerve-grafts had been inserted in 5 cats and degenerated grafts in a similar number. Since the upper end of the graft was about 6 cm. proximal to the site of division and suture in the nerve-suture experiments, we did not anticipate recovery of motor function in the grafting experiments for some twenty to thirty days more than the 35 days taken after nerve-suture. Accordingly we did not commence to stimulate the nerve until 57 days after operation. As motor recovery was found in some instances at that time it may be that the earliest stages of recovery were missed, for an experiment that showed such a recovery on the 57th day might have shown recovery a few days earlier. The purpose of the serial sections of the whole length of nerve, however, was to provide a record of the extent of regeneration, and in comparing the results of fresh and degenerated nerve-grafts we have based our opinion on the extent of nerve regeneration shown in the preparations, as well as on the results of stimulation.

The distance from the proximal suture line to the farthest point that new axonal growth could be traced was measured in each case. The figure is not accurate to more than 1 cm. or so, since the thin terminal portions of the nerve stained unequally, and it was difficult at times to be certain whether nerve-fibres were present in the end segment or not. There can be little significance, however, in a small difference in the extent of nerve-axon growth in two cases, since variations in rate of growth and in accuracy of approximation and in scar-tissue formation at the suture lines will readily cause differences in the regenerative processes, and it is only a large difference in these processes, such as the one described by Duel and Ballance, that can be of significance in a comparison of this kind.

Table II gives the results of the experiments. It will be seen that *Cat* 1 (58-day fresh-graft experiment) is to be compared with *Cat* 6 (57-day degenerated-graft experiment). It appeared at first that here was an advantage of the degenerated graft over the fresh, since there was recovery of motor function in the former and not in the latter; but measurement showed that the degenerated graft had been inserted 0·5 cm. more peripherally than the fresh, and that the actual distance the axons had grown in the two cases was the same (15·5 and 16·0 cm.).

Cat 2 (61-day fresh-graft experiment) and *Cat* 8 (59-day degenerated-graft experiment) are comparable. In the fresh-graft experiment there was a small muscular contraction, indicating that relatively few axons had reached the muscle, and new nerve-fibres could be traced 15·5 cm. along the nerve. In the degenerated-graft experiment there was also a small muscular contraction, and the distance of new fibre growth was 17·0 cm. The grafts in these two experiments had been inserted at a similar height in the thigh (10 cm. above the motor branch in each case), and the comparison is therefore just.

Table II.—Results of Auto-graft Experiments

No. of Cat	Number of Days Degeneration of Graft	Number of Days between Operation and Subsequent Exposure and Stimulation	Movements of Extensor Tendons as Result of Nerve Stimulation	Distance from Proximal End of Graft to Motor Branch	Total Distance New Axons have Grown
Fresh-nerve Graft				cm.	cm.
1	—	58	−	10·5	16·0
2	—	61	+ (very slight)	10·0	15·5
3	—	64	+	8·8	17·5
4	—	73	+	8·5	17·5
5	—	88	+	9·0	18·5
Degenerated-nerve Graft					
6	15	57	+	10·0	15·5
7	17	58	died before stimulation	10·5	14·0
8	17	59	+ (very slight)	10·0	17·0
9	14	60	−	10·5	16·0 (but very few fibres)
10	14	73	+	8·8	17·0

Cat 3 (64-day fresh-graft experiment) is to be compared with *Cat* 9 (60-day degenerated-graft experiment). Motor recovery had occurred in the former but not in the latter, but it must be noted that the fresh graft was situated 1·7 cm. more peripherally than the degenerated graft. Nerve-axons had, however, grown a greater distance in the fresh-graft experiment than in the degenerated one.

Thus in the three fresh-graft experiments stimulated about the sixtieth day after operation (*Cats* 1, 2, and 3), there was recovery of motor function in two, and the average distance the nerve-fibres had grown was about 16 cm. In the three corresponding degenerated-graft cases there was recovery of motor function in two, and the average length of new axonal growth was also about 16 cm.

At 73 days motor activity was present in both types of experiment (*Cats* 4 and 10), and in each nerve-fibres could be traced about 17 cm.

We have thus not found any obvious difference in the time taken for recovery of motor function or in the distance that the new axons have grown in a given time between the fresh- and degenerated-nerve-graft experiments. It was possible, moreover, to obtain further comparison from the sections of the grafts and nerves at different levels.

At the 60-day period both types of grafts were packed with nerve fibres, and in no case was there any obvious diminution in the number of fibres in one graft compared with the others (*Figs.* 252, 253). The age of the fibres as judged histologically was also much the same. In nerve-regeneration preparations the older of the new axons are thick and stain brown, while the young, more recently grown, fibres are finer and stain dark black. In the 6 experiments examined around the 60-day period the proportion of thick and fine fibres was very comparable in the two types of graft, and it was evident that a preponderance of the thicker, older fibres did not belong to either fresh or degenerated grafts (*Figs.* 254, 255).

The number of fibres seen in segments of nerve remote from the graft (e.g., segment 3, or A, in *Fig.* 249) also afforded a good basis of comparison of the extent

FIG. 252.—Longitudinal section of fresh auto-graft, 58 days after operation (*Cat* 1). Full width of graft. Note presence of nerve-fibres, and compare with *Fig.* 253. (× 28.)

FIG. 253.—Longitudinal section of degenerated auto-graft, 59 days after operation (*Cat* 8). Full width of graft. Note presence of nerve-fibres, and compare with *Fig.* 252. (× 28.)

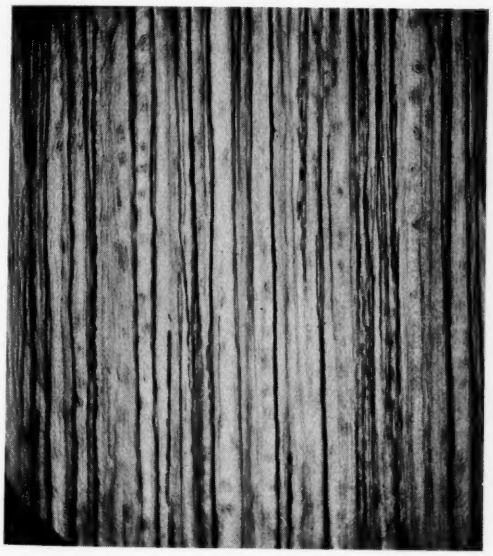


FIG. 254.—Higher magnification of graft shown in *Fig.* 252. Note proportion of thick and fine fibres, and compare with *Fig.* 255. (× 135.)

FIG. 255.—Higher magnification of graft shown in *Fig.* 253. Note proportion of thick and fine fibres, and compare with *Fig.* 254. (× 135.)

of regeneration, and on this basis the extent of regeneration in the two series of experiments was again found to be indistinguishable. Where equal accuracy of

approximation had been obtained at operation very similar numbers of fibres were observed in the nerves at equal distances below fresh and degenerated grafts (*Figs.* 256, 257).

FIG. 256.—Longitudinal section of nerve 6 cm. distal to fresh auto-graft, 58 days after operation (*Cat* 1). Full width of nerve. Note presence of nerve-fibres, and compare with *Fig.* 257. (× 135.)

FIG. 257.—Longitudinal section of nerve 6 cm. distal to degenerated auto-graft, 59 days after operation (*Cat* 8). Full width of nerve. Note presence of nerve-fibres, and compare with *Fig.* 256. (× 135.)

FIG 258.—Longitudinal section of peripheral end of nerve divided in situ, after 13 days. Note new nerve-fibres lying between old neurilemmal tubes. (× 320.)

Observations on the histological preparations therefore confirmed the similarity of the regenerative processes in the two types of experiment.

FIG. 259.—Longitudinal section of proximal suture line of fresh auto-graft experiment, 58 days after operation (*Cat* 1). Full width of anastomosis. Note amount of scar producing deviations of the nerve-fibres, and compare with *Figs.* 260, 261, and 262. A, Proximal nerve entering the anastomosis S, Suture, marginally placed. (× 28.)

FIG. 260.—Longitudinal section of proximal suture line of fresh auto-graft experiment, 64 days after operation (*Cat* 3). Full width of anastomosis. Note amount of scar producing deviations of the nerve-fibres, and compare with *Figs.* 259, 261, and 262. A, Proximal nerve entering the anastomosis; S, Suture, marginally placed. (× 28.)

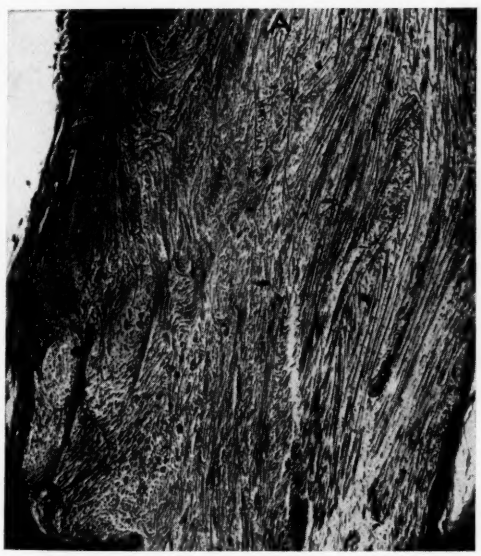


FIG. 261.—Longitudinal section of proximal suture line of degenerated auto-graft experiment, 60 days after operation (*Cat* 9). Full width of anastomosis. Note amount of scar producing deviations of the nerve-fibres, and compare with *Figs.* 259, 260, and 262. A, Proximal nerve entering the anastomosis. (× 28.)

FIG. 262.—Longitudinal section of proximal suture line of degenerated auto-graft experiment, 57 days after operation (*Cat* 6). Full width of anastomosis. Note amount of scar producing deviations of the nerve-fibres, and compare with *Figs.* 259, 260, and 261. A, Proximal nerve entering the anastomosis. (× 28.)

It is of interest to consider here the two remaining theoretical conceptions on which Duel and Ballance had explained their results.

Obstruction of the Neurilemmal Tubes of the Fresh Graft by Unabsorbed Products of Wallerian Degeneration.—This argument implies that the old neurilemmal tubes remain patent and that all the new nerve-fibres traverse these tubes. This conception is not borne out in our studies. New axons certainly grow along a graft in lines parallel to those of the old fibres, so that when growth is complete the graft is occupied by fibres running vertically and orderly from one end of the graft to the other (*see Figs.* 252–255). What provides the directing scaffolding is not certainly known. Weiss considers it to be the pattern of the colloidal ground substance of the nerve, and it is therefore of significance to note that new fibres may lie between the sheaths of the old neurilemmal tubes as well as inside them (*Fig.* 258). These fibres at least cannot be obstructed by the incompletely absorbed lipoidal products of Wallerian degeneration within the tubes; and, although we have not made special preparations to study this point, it does not appear reasonable that a fibre that can grow across a connective-tissue scar barrier at the suture lines, will find any obstruction in an intermittent lipoidal collection in the graft.

It is of significance also that Speidel[17, 18] has shown that the myelin and neurilemma sheaths of a new nerve-fibre develop from cells in the growth-bud of the fibre itself, both sheaths thus being formed anew in regeneration.

Blocking of the Ends of the Fresh Graft by Fibrous-Tissue Reaction.—If any reaction took place it would be apparent in the sections of the suture lines between graft and nerve. It is obvious, however, in our preparations that there is no constant increase in the amount of fibrous tissue at the suture lines of the fresh graft compared with the degenerated graft (*Figs.* 259–262). Variations in the amount of scar between one experiment and another exist, but the differences appear to depend on variations in accuracy of approximation of the ends of the graft and nerve, and where accurate approximation was obtained the amount of scar at the suture line was much the same in the two types of experiment.

We have been impressed in our experiments by the influence that scar formation at the suture lines has on the passage of nerve-fibres into the distal segment of nerve. We said above that at operation we placed great importance on the technique and accuracy of suturing, aiming to pass the sutures—one on either side—through the sheath only of the nerve and graft and to approximate the cut ends of the graft to the nerve snugly and smoothly. Histological sections subsequently prepared show that we have not always been completely successful in this, and that the effect of even a small inaccuracy in approximation, or of invasion of the nerve or graft by the suture, is the production of scar tissue at the suture line, which varies in amount according to the degree of inaccuracy or invasion.

Fig. 263 represents the proximal suture line between the nerve and a 15 days' degenerated graft six days after operation, before scar tissue has begun to form. The sutures are marginally placed, and the graft is approximated to the nerve accurately and without distortion. This we look upon as the ideal operative result, and is what we aimed at—though not always successfully. Where satisfactory approximation was obtained, the amount of scar occurring 60 to 70 days later was small, and comparatively little obstruction to the downgrowth of nerve-fibres was

produced (*see Figs.* 259–262), so that in the nerve distal to the graft large numbers of axons were present (*Figs.* 256, 257), showing that the grafts had functioned efficiently.

Where, however, satisfactory approximation had not been obtained, a large scar resulted 60 to 70 days after operation. *Fig.* 264, prepared from the lower suture line of a 14-day degenerated-nerve-graft experiment 60 days after operation (*Cat* 9), shows such a result. In this experiment, the graft at operation was taken from a lower level in the left thigh than usual, and was found to be divided inside the sheath, at its lower end, into two branches. It was very difficult to approximate these two divisions accurately and smoothly to the end of the nerve, and although at the end of the operation the suturing did not appear too bad, the result 60 days

FIG. 263.—Longitudinal section of proximal suture line of degenerated auto-graft experiment, 6 days after operation. Note accurate approximation with absence of distortion. A, Proximal nerve entering anastomosis; S, Suture, marginally placed. (× 40.)

later was illuminating. A very extensive dense scar had formed in which large numbers of axons had become obstructed and lost, and consequently in the nerve below the graft very few fibres were present (*Fig.* 265)—in marked contrast to the condition of the nerve below the graft where scar formation at the suture lines had been minimal (*see Figs.* 256, 257).

This illustrated well the effect of scar at the suture lines on the passage of nerve-axons, and we have found in all instances where the anastomosis at operation was not perfectly satisfactory, and accurate end-to-end approximation was not obtained, that a fibrous scar formed at the suture line, in which large numbers of the growing axons became lost. Davis and Cleveland[2] in a recent communication have been similarly impressed by the obstructive effects of scar formation, particularly at the

distal suture line, and in a series of experiments in dogs have practised excision of the distal anastomosis and re-suture at a time when the new axons were calculated to be at the lower end of the graft: the axons, therefore, had an equal start with the connective-tissue growth in the anastomosis and could grow through into the nerve before a dense scar had formed. This method resulted in a great increase in the number of fibres reaching the distal segment of nerve.

The value of the procedure must depend on the length of graft employed. In our experiments with grafts 3 cm. in length, the amount of scar at the distal anastomosis where accurate approximation had been obtained was sufficiently small to permit the passage of the growing fibres. With longer grafts, 7 cm. in length, as used by Davis and Cleveland, the distal scar has longer time to thicken, contract, and form a relatively impassable barrier before the nerve-fibres reach the anastomosis, so that the procedure recommended by these authors would clearly be of value.

FIG. 264.—Longitudinal section of distal suture line of degenerated auto-graft experiment, 60 days after operation (*Cat* 9). Note bifurcation of nerve entering anastomosis, and extensive dense scar that has formed. A, Proximal nerve entering the anastomosis; S, Suture, marginally placed. (× 16.)

FIG. 265.—Longitudinal section of nerve 6 cm. distal to anastomosis shown in *Fig.* 264. Full width of nerve. Note very few fibres present, and compare with *Figs.* 256 and 257. (× 135.)

The poor clinical results recorded after the war may, we suggest, be explained on the basis of scar-tissue formation. In most of those cases the nerve gap was bridged by cable grafts—multiple strands of cutaneous nerve, often arranged around a catgut strand running between the two ends of the nerve and enclosed in a connective-tissue sheath. Our experiences suggest that under such conditions fibrosis would be so extensive as to prevent any nerve-fibres reaching the distal end of the nerve. A certain amount of scar formation at the anastomosis is inevitable, but must be kept to a minimum if a functional result is to be obtained, and we suggest that in order to ensure a satisfactory result two things are essential: firstly, meticulous care and accuracy of technique in suturing; and secondly, employment of a graft of the same calibre as the nerve, so that accurate approximation of the cut end of the graft and nerve can be obtained.

In autogenous nerve-grafting, therefore, we do not confirm Duel and Ballance's results, and find that with equal accuracy of approximation a fresh graft functions as efficiently as a degenerated one, and that the deciding factor in obtaining a successful result in nerve-grafting is the amount of scar at the anastomosis. In this last factor may lie the explanation of Duel and Ballance's results. When a nerve undergoes Wallerian degeneration in situ for ten to fourteen days, it becomes firmer and stiffer, and if a graft is taken from such a nerve its cut ends tend to remain circular and patent. A piece of fresh nerve, on the other hand, is soft and friable, and the cut ends, being of the consistency of butter, tend to become crushed and collapsed. Satisfactory approximation of graft and nerve can therefore be obtained more readily with a degenerated graft than with a fresh one, and this advantage would no doubt be particularly valuable in grafting the facial nerve in its bony groove, where the ends of the graft and nerve are simply laid against each other and coaptation by sutures is impossible.

We know from our results that the more accurate the approximation the less scar tissue is formed, and that with less scar the growth of nerve axons into the distal end of the nerve is facilitated, and we suggest this as a possible explanation of Duel and Ballance's findings.

b. HOMEO-GRAFT.—If it is accepted that cable grafts are unsuitable for nerve-grafting and that a graft of equal calibre to that of the recipient nerve is necessary, then in the case of the limb nerves grafting becomes impracticable unless it is shown that a nerve taken from another individual can be used as a graft.

Homeo-graft experiments were carried out in seven cats, in each of which a fresh graft was placed in the left external popliteal nerve and a degenerated graft in the right. The results are shown in *Table III.*

Physiological Findings.—The earliest date at which return of motor function was found was 78 days after operation (*Cat* 15), when motor activity was present on both sides. In this experiment, however, the grafts were a little shorter than usual—2 cm. instead of 3 cm.—so that it is likely that return of function would have taken rather longer if the graft had been the usual length.

Table III.—RESULTS OF HOMEO-GRAFT EXPERIMENTS

No. of Cat	Number of Days Preliminary Degeneration of Graft on Right Side	Number of Days between Operation and Subsequent Exposure and Stimulation of Nerves	Movements of Extensor Tendons as Result of Stimulation of Nerve	
			Right Side (degenerated graft)	Left Side (fresh graft)
11	15	Cat died on 6th day after operation	—	—
12	10	44	—	—
13	24	58	—	—
14	14	59	—	—
15	17	78	+	+
16	14	Stimulated aseptically at 76 days	—	—
		Stimulated again at 91 days	—	+
17	14	96	+	+

FIG. 266.—Longitudinal section of fresh homeograft, 96 days after operation (*Cat* 17). Full width of graft. Note: (1) Great number of fibres within graft; (2) Greatly thickened sheath full of distended blood-vessels. Compare with *Fig.* 267. (× 28.)

FIG. 267.—Longitudinal section of fresh autograft, 88 days after operation (*Cat* 5). Full width of graft. Note: (1) Great number of fibres within graft; (2) Thin sheath with few blood-vessels. Compare with *Fig.* 266. (× 28.)

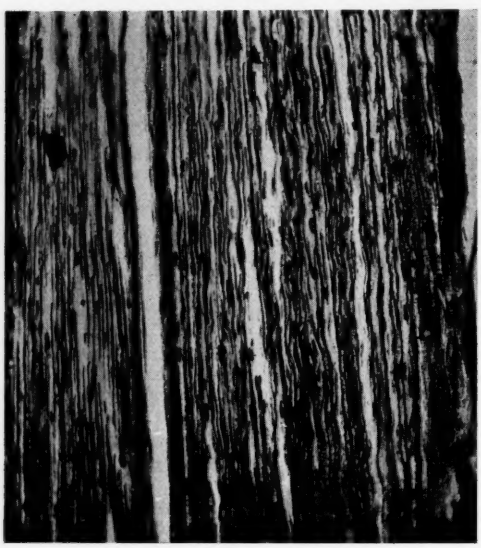


FIG. 268.—Longitudinal section of nerve 6 cm. distal to homeo-graft shown in *Fig.* 266. Full width of nerve. Note presence of nerve-fibres, and compare with *Fig.* 269. (× 135.)

FIG. 269.—Longitudinal section of nerve 6 cm. distal to auto-graft shown in *Fig.* 267. Full width of nerve. Note presence of nerve-fibres and compare with *Fig.* 268. (× 135.)

At 91 days (*Cat* 16) there was return of motor activity on the side of the fresh graft, but not on the side of the degenerated one; this cat was extremely large, and the external popliteal nerves correspondingly long, so that the distance from the upper anastomosis to the motor branch was 13·0 cm., and not the customary 10 cm., on each side, which in part explains the long interval before return of function. It is interesting to note that return of function first occurred on the side of the fresh graft. Unfortunately the nerve-axons did not take the silver stain, and it is therefore impossible to determine from the histological preparations the details and extent of nerve-fibre growth.

At 96 days (*Cat* 17) both sides showed return of motor function, so that it is evident that a homeo-graft will serve to bridge a 3-cm. nerve gap, although it appears that the nerve-fibres take longer to grow through the graft than they do through an autogenous one.

FIG. 270.—Longitudinal section of fresh auto-graft, 58 days after operation (*Cat* 1), counter-stained (saffronin) to show cellular constituents. Note leucocytes arranged chiefly along the strands of apparently structureless material lying between the new nerve-fibres. (× 135.)

FIG. 271.—Longitudinal section of fresh auto-graft, 88 days after operation (*Cat* 5), counter-stained (saffronin) to show cellular constituents. Compare with *Fig.* 270, and note: (1) Absence of leucocytes; (2) Absence of structureless strands; (3) Graft composed of new fibres plus their cellular sheaths. (× 135.)

Histological Findings.—The histological findings confirm this observation. At the 60-day period nerve-fibres have passed the graft, but the fibres are of a younger type than in the corresponding auto-graft, and instead of the total distance of new axon growth being about 16 cm. it is only about 11 cm. on both fresh and degenerated sides. At 96 days, however, large numbers of fibres have passed the graft and are present in considerable numbers in the most distal segments examined (ankle level): there is no obvious difference between the extent of regeneration in this experiment and that in the 88-day fresh auto-graft (*Figs.* 266–269), so that once the original delay is overcome the final result is much the same.

The delay is due to the reaction that the homeo-graft evokes, a reaction in marked contrast to the moderate changes involving the auto-graft.

At 59 days an *auto-graft* is invaded by capillaries and leucocytes. The capillaries have grown in from the margin and branch freely within the graft; the leucocytes are full of granular material and are arranged along the lines of the nerve-fibres, and congregate especially in relation to the unabsorbed structureless strands lying between the new axons (*Fig.* 270).

Except at the suture lines, where scar tissue tends to spread intraneurally a short way into the graft and nerve, there is no invasion of the graft by connective tissue from the sheath or along the capillaries growing in from the margins.

At 73 days very few of the structureless strands within the graft remain, and the leucocytic invasion is less marked. At 88 days there is very little of the original

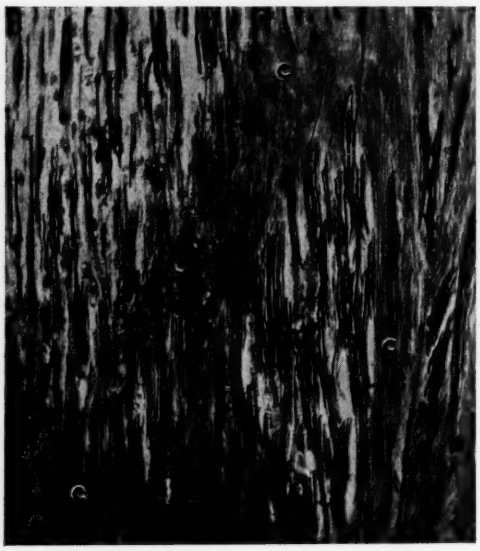


FIG. 272.—Longitudinal section of fresh homeo-graft, 59 days after operation (*Cat* 14), counter-stained (saffronin) to show cellular constituents. Note: (1) Invasion of graft by connective-tissue strands from the sheath; (2) Accumulation of large numbers of leucocytes within the graft. C, Connective-tissue strand. (× 135.)

FIG. 273.—Longitudinal section of another part of the graft shown in *Fig.* 272. Note accumulation of leucocytes. (× 135.)

structure of the graft to be seen, leucocytes have disappeared almost completely, and the graft appears to be composed almost entirely of new fibres, each lying within its new cellular sheath (*Fig.* 271).

The appearances suggest that the original internal structure of the graft, whilst temporarily providing a scaffolding for the new nerve-fibres, is ultimately absorbed by leucocytic activity.

The *homeo-graft*, on the other hand, evokes a severe local reaction, as would be expected to result from the introduction of a foreign tissue into the animal body. Loeb has shown the stages of the reaction of host tissues to homeo- and hetero-grafts (other than nerve-grafts), which results in their destruction and absorption. These observations have been confirmed by many

workers, so that it is at first sight surprising that the introduction of a homeo-nerve-graft resulted in restoration of continuity and function of the nerve.

At the exposure of the nerve 40 or more days after operation, the homeo-graft was always much more adherent to the surrounding tissues, particularly at the suture lines, but also along its length, than in the case of the auto-graft. Sections prepared 60 days after operation show very large numbers of leucocytes within the graft, and in places growing into the graft from the sheath strands of connective tissue sometimes surrounding a small central blood-vessel. The leucocytes tend to cluster around these connective-tissue strands, and are large, swollen, and packed with granular material (*Figs.* 272, 273). This reaction is much the same in both fresh and degenerated homeo-grafts.

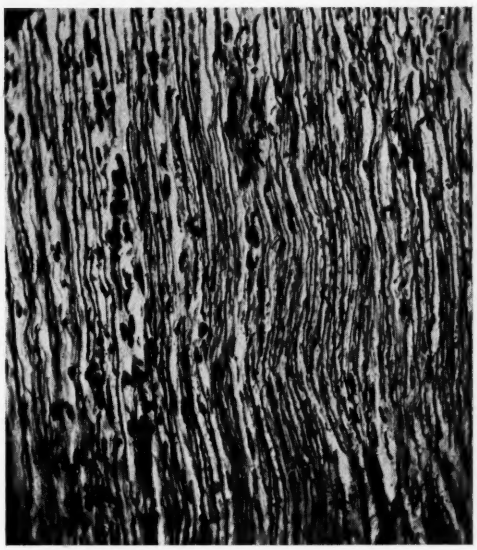


FIG. 274.—Longitudinal section of fresh homeo-graft 96 days after operation (*Cat* 17), counter-stained (saffronin) to show cellular constituents. Note: (1) Reduction in number of leucocytes compared with 59-day homogenous graft (*Fig.* 272); (2) Absence of invading connective-tissue strands; (3) Graft composed of new fibres plus their cellular sheaths. Compare with *Fig.* 271. (× 135.)

In addition, aggregations of large numbers of cells occur particularly at the suture lines and under the sheath of the graft. Each aggregation consists of a hundred or more round structureless cells; the appearances are those of collections of dead leucocytes, but their localized nature, almost suggesting multiple minute abscesses, is hard to explain.

At 96 days this marked foreign-body reaction is considerably modified (*Fig.* 274). Large numbers of active granular leucocytes are still within the graft, but the invading connective-tissue strands have gone; there is, too, little to be seen of the original structure of the graft, which appears to be composed entirely of nerve-axons each with its new cellular sheath. Apart from the large number of leucocytes still within the graft the condition closely resembles that of the auto-graft. The aggregations of cells beneath the sheath are still present, but are becoming organized.

It is thus seen that the foreign tissue of the graft is partly absorbed by leucocytic activity and partly replaced by connective-tissue invasion, but that this invasion by fixed tissue cells is in its turn absorbed, and the final structure of the graft appears to be made up of a new growth from the proximal end of the nerve, as in the case of the auto-graft.

Although the internal structure of the graft is absorbed in this way, it must in its early stages provide the necessary scaffolding for the new growing fibres; it is obvious, however, that the connective-tissue invasion will hold up their growth, and this must in part be responsible for the delay in passage of fibres through the homeo-graft compared with the auto-graft. But the delay must also be due in part to reaction at the suture lines, where a marked connective-tissue reaction takes place which is not absorbed and forms an appreciable scar at the anastomosis. This scarring is in considerable excess of that occurring in the auto-graft experiments, where good approximation was obtained. In our experiments with grafts 3 cm. long, fibres are able to pass into the distal end of the nerve in as great numbers as through the auto-graft, although their passage is delayed. With a graft three times as long, however, the corresponding increase in length of connective-tissue-invaded graft through which the fibres must grow, plus the scarring at the suture lines, might prove a considerable barrier to nerve-axon growth. We must conclude, therefore, that though a homeo-graft will bridge successfully a short nerve gap, the fate of the growth of nerve-fibres through a long homeo-graft still requires experimental investigation.

SUMMARY

1. Nerve-suture and nerve-grafting experiments have been performed in the cat.

2. It is shown that a nerve gap 3 cm. in length can be bridged by a nerve-graft so that the anatomical and physiological continuity of the nerve is restored.

3. The advantages claimed for a degenerated nerve-graft over a fresh graft are not confirmed, and it is found that the results after fresh- and degenerated-nerve-grafting are indistinguishable.

4. The reduction of scar tissue at the suture lines is shown to be of the greatest importance in obtaining a successful result.

5. In order to reduce scar tissue to a minimum, two factors are considered to be essential: firstly, accuracy of approximation of nerve and graft; and secondly (a corollary of the first), a graft of equal calibre to the recipient nerve.

6. Nerve gaps 3 cm. in length have been satisfactorily bridged by homeo-nerve-grafts, but it is not possible to say whether longer grafts would function as efficiently.

The authors wish to acknowledge their indebtedness to the late Sir Charles Ballance, with whom this investigation was begun. Although Sir Charles's illness soon caused him to stop active work, the present authors owe a great deal to the stimulus of his enthusiastic and critical mind. They wish also to express their thanks to Mr. S. P. Steward, Mr. F. Watson, and the Technical Staff of the Royal College of Surgeons Laboratories for their willing and skilful help throughout this work.

REFERENCES

[1] STOOKEY, *Surgical and Mechanical Treatment of Peripheral Nerves*, 1922. Philadelphia: Saunders.
[2] DAVIS and CLEVELAND, *Ann. of Surg.*, 1934, Feb., 271.
[3] NAGEOTTE, *Revue neurol.*, 1920, xxvii, 1131.
[4] SENCERT, *Presse méd.*, 1918, xxvi, 656.
[5] DUSTIN, *Comptes rend. Soc. de Biol. de Paris*, 1919, lxxxii, 614.
[6] STOPFORD, *Lancet*, 1920, ii, 1296.
[7] PLATT, *Brit. Jour. Surg.*, 1919–20, vii, 384.
[8] PLATT and BRISTOW, *Ibid.*, 1923–24, xi, 535.
[9] DUEL and BALLANCE, *Arch. of Otolaryngol.*, 1932, xv, 1.
[10] DUEL and BALLANCE, *Ibid.*, xvi, 767.
[11] TELLO, *Trab. del Lab. de Investig. Biol.*, 1911, ix, 123.
[12] CAJAL, *Degeneration and Regeneration of the Nervous System*, 1928, i, 361.
[13] BALLANCE, *Jour. Laryngol. and Otol.*, 1934, xlix, 709.
[14] DUEL, *Surg. Gynecol. and Obst.*, 1933, lvi, 382.
[15] DUEL, *Brit. Med. Jour.*, 1934, ii, 1027.
[16] WEISS, *Jour. of Exper. Zoöl.*, lxviii, 293.
[17] SPEIDEL, *Ibid.*, lxi, 279.
[18] SPEIDEL, *Amer. Jour. Anat.*, 1933, lii, 1.

AN EXPERIMENTAL STUDY OF THE RETURN OF FUNCTION AFTER TENDON SECTION

By D. STEWART

FROM THE DEPARTMENT OF ANATOMY, MANCHESTER UNIVERSITY

INTRODUCTION

DURING recent years the natural processes by which cut tendons are repaired have interested a large number of Continental workers, and a considerable literature has grown up around this subject. Very little of this work has appeared in the English language, and it would therefore seem that the problem has not been very closely studied by either British or American workers. Mason and Shearon (1932) published a paper on the process of tendon repair in which they included an extensive survey of the Continental work. An excellent account of the early work was given by Adams (1860) in his book on the reparative processes in human tendons, which laid the solid foundations of our knowledge of tendon repair. It is therefore not considered necessary in this communication to give a formal review of the literature, which would occupy more space than would be justified in a paper of this nature. Reference will only be made to those papers which have a direct bearing upon the aspects of the problem which have been investigated in the present inquiry.

The present research arose out of an investigation which the author had conducted by means of slow motion cinematography into the alterations which occur in the gait after the tendons of various muscles have been cut. In that investigation, the author used rabbits, guinea-pigs, and cats, and the tendons divided were those of the distal region of the hind limb. Two guinea-pigs, in which all the tendons on the posterior aspect of both the hind limbs immediately above the ankle had been severed, were kept for several months, when it was discovered that their gait had practically returned to the normal. The animals were killed and post-mortem examinations were made. Macroscopically, it was found that the divided tendons had been re-formed, and histological examination revealed that the newly formed tissue closely resembled normal tendon tissue in its structure. This discovery appeared to justify a special investigation into this aspect of tendon repair, and a series of experiments was performed upon three cats (Nos. 3, 6, and 7). These experiments form the basis of the present communication. The cat was selected as the experimental animal because, being digitigrade, section of the muscles of the region of its calf causes much greater alteration in its gait than a similar operation on the plantigrade guinea-pig.

TECHNIQUE

The animal was anæsthetized and an incision was made, with the usual aseptic precautions, along the inner border of the superficial tendons of the foot immediately above the heel. The sheath of these tendons was cleaned, opened, and the

structures within it exposed. In the cat these structures are two in number—the tendo Achillis, formed by the fusion of the tendons of the gastrocnemius and the soleus, and the tendon of the large plantaris muscle, which is a separate entity. After they had been exposed, about half an inch of each of the tendons was removed and the muscle bellies were allowed to retract. It was difficult to estimate the exact length of the gap between the ends of the tendons after the retraction, but it was about ¾ to 1 in. in length. The deep tendons were next exposed and divided. There was practically no bleeding during the operation, and after the deep tendons had been divided the skin incision was closed with horsehair sutures. The operation was then repeated on the other leg. The animals received no further treatment, and were merely confined in a large room in which they could move about quite freely. There was no sign of sepsis during the recovery period and the wounds healed by first intention.

CINEMATOGRAPH ANALYSIS

Before the operations were performed, a 16-mm. cinematograph film was made of the normal gait of the animals. A week was allowed to elapse after operation to allow the animals to recover from post-operative stiffness, and a further film was made. At the end of the second week, the gait of the animals resembled so closely that at the preceding week that it appeared to be unnecessary to make further pictures at this stage and cinematography was therefore postponed till the end of the third week. After this, the films were made at weekly intervals—namely, at the fourth, fifth, and sixth week. At the end of this period the experiments were concluded, by sacrificing the animals. To facilitate the analysis of the variations in the gait of the animals at the different phases of the experiments, the films were taken at the rate of 64 frames per second. Therefore, when they were projected on the screen, the animals appeared to be walking at a quarter the normal rate.

In presenting accounts of research work involving cinematography, authors labour under the handicap that the readers are not able to see the actual film and may therefore have some difficulty in following the description. To overcome this obstacle to a certain extent, I have made a series of outline drawings of the hind-quarters of one of the animals by projecting the film on to a roll of paper and tracing the position of the limbs in every third frame throughout a complete cycle of movement (*Fig.* 275).

It is customary to divide the locomotory cycle of a limb into two parts—(1) the support stage, when the limb is in contact with the ground and is supporting the weight of the animal, and (2) the suspense stage, when the limb is off the ground.

Normal Gait (*Fig.* 275*a*).— The normal gait of the cat is definitely digitigrade, and at no part of the support stage does the posterior portion of the foot come in contact with the ground. At the start of this stage, only the toe region of the foot reaches the ground and the heel is well raised from it. As the weight of the animal is brought on to the supporting limb, the heel is gradually lowered, but is always well above the horizontal. In the latter part of the support stage, the heel gradually rises to and beyond the perpendicular. At the start of the suspense period, the foot at first inclines still further beyond the perpendicular, but very rapidly returns to that position. As it is carried forward in the latter part of suspense, the fore-part of the foot becomes raised, and the whole foot comes nearer to the horizontal than at any other point in the locomotory cycle.

Gait One Week after Operation (*Fig.* 275*b*).—The animal is now completely plantigrade during the greater part of the support period. At the start of this stage, the fore-part of the foot may first of all make contact with the ground, but if this happens it is immediately followed by the remainder of the foot. On the other hand, the whole of the plantar surface of the foot may come to the ground at one time. During the greater part of the support period, the whole of the foot remains in contact with the ground, and only towards the end of this stage is the heel raised from the ground. This raising of the heel appears to be distinctly passive, due to the animal being pulled forward by its fore-limbs with little active

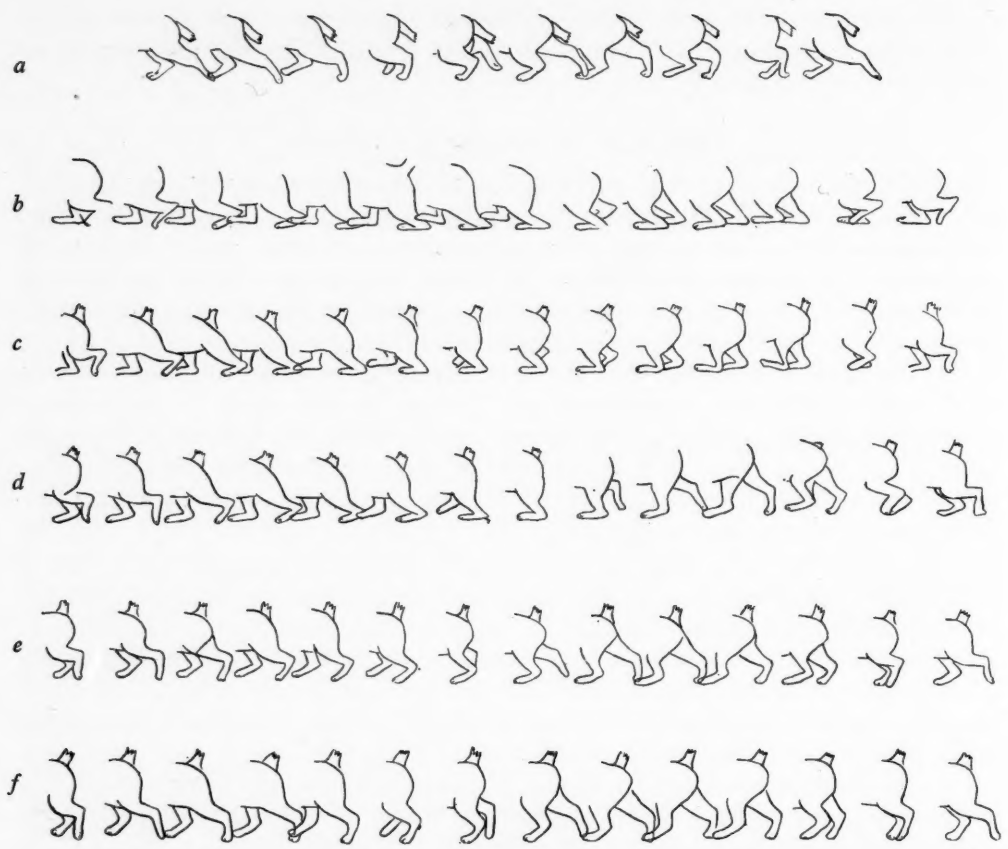


FIG. 275.—Tracings of gaits of cat from cinematographic films. *a*, Before operation; *b*, One week after operation; *c*, Three weeks after operation; *d*, Four weeks after operation; *e*, Five weeks after operation; *f*, Six weeks after operation. The tracings start from the right of the figure.

assistance from the muscles of the leg. The foot is rolled forward and does not reach the perpendicular position. The suspense period begins by the foot being lifted from the ground by the action of the thigh muscles. It is then carried forward, but to a much less extent and less efficiently than in the normal animal. In the suspense period the fore-part of the foot is held relatively much higher than in the normal animal, so that the toes are at the same height as the heel or may even be raised above it. The action of the whole of the hind-quarters region is stiff and inefficient.

Gait Three Weeks after Operation (*Fig.* 275*c*).—Although the animal is still completely plantigrade during the greater part of the support period, the hind-limbs move more freely and their muscles are taking a much more active part in the movements than they did a week after operation. The limb below the knee is now more perpendicular during the earlier stage of support, indicating that it is resisting the weight of the animal and is now not passively yielding. During suspense, the hind-limb appears actively to assist the carrying forward of the foot, and this movement is now more extensive.

Gait Four Weeks after Operation (*Fig.* 275*d*).—There is a very marked improvement in the gait and the movements of the hind-limbs are much freer. At the start of support the fore-part of the foot of the animal makes contact with the ground, but the calcaneal region sags very rapidly and the fully plantigrade position is reached. During the latter part of the support period, the heel is raised from the ground by muscular action and is not passively rolled upwards as before. At the end of support and the start of suspension, the foot approaches nearer to the perpendicular, and when it is carried forward the heel is always higher than the toes.

Gait Five Weeks after Operation (*Fig.* 275*e*).—The gait has now almost resumed its normal form. Close observation, however, shows that at the start of support more of the anterior portion of the foot is on the ground than in the normal animal. Also, as the weight comes on to the foot, the heel approaches more closely to the ground than before operation.

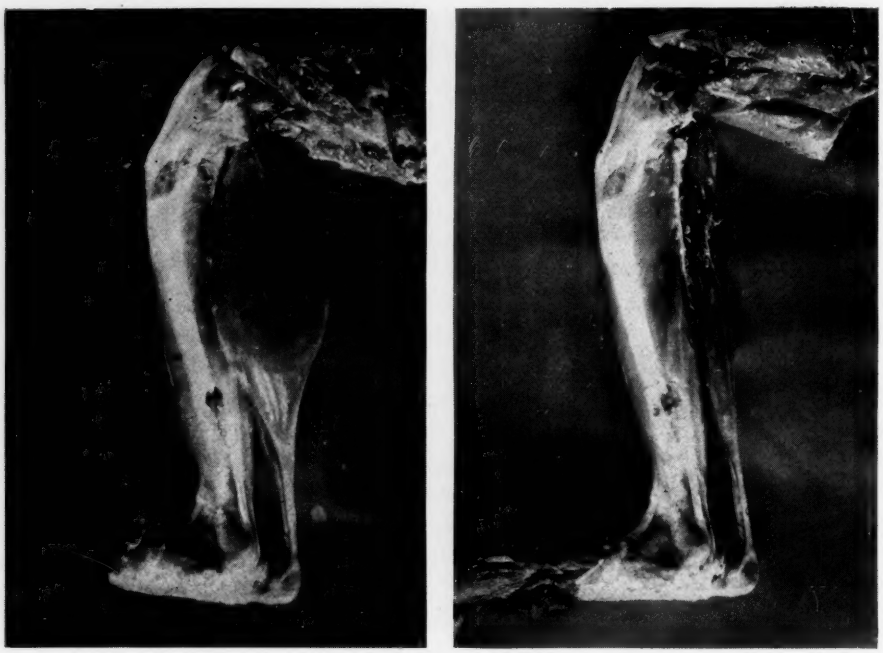
Gait Six Weeks after Operation (*Fig.* 275*f*).—The gait appears to be exactly similar to that of the normal animal.

During the period of six weeks that the animals were kept after operation, the hind-quarters were examined at frequent intervals. At first there was no resistance at the site of operation and the posterior surface of the bone could be palpated easily through the skin. Later, there occurred a steady thickening at the site of operation and an increasing resistance to the fingers. Towards the end of the period, a definite rounded strand similar to a tendon could be felt. The skin was freely movable over this structure.

The critical stage of these experiments was during the fourth week after operation, and it is obvious that at this time sufficient regeneration had occurred to allow the divided muscles to recommence functioning. There is an interesting parallel to this result in the work of Gaza, Gerlach, and Gissel (1932), who studied the metabolic changes in the regenerating tissue at different stages of tendon regeneration. They found that after tendon section, the metabolic activity of the tissue uniting the ends of the tendons steadily increased up to 18 days. After this it gradually sank until it reached that of normal tendon. From the results of these workers and those of the present research, it would appear that some marked change takes place about the third week in the tissue filling the gap between the tendons, and it is suggested that this may be the commencing transformation of some tissue, resembling granulation tissue, into tendon. This is supported by the work of Bloch and Bonnet (1929), who found histologically that towards the end of the third week the tissue filling the gap began to resemble tendon.

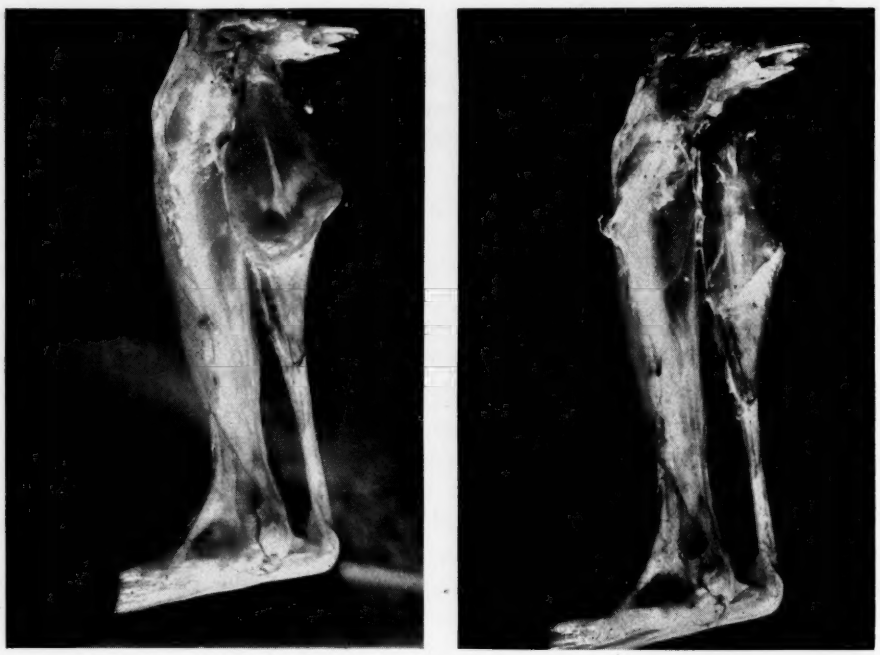
POST-MORTEM RESULTS

After six weeks the cats were killed and a post-mortem examination was made. For comparison, a similar examination was done on a normal cat (*Fig.* 276).



a *b*

FIG. 276.—Dissections of the hind limb of normal cat. *a*, The skin and fascia have been removed and the superficial muscles and tendons cleaned ; *b*, As (*a*), but the gastrocnemius muscle and the tendo Achillis have been removed to expose the plantaris muscle and tendon.

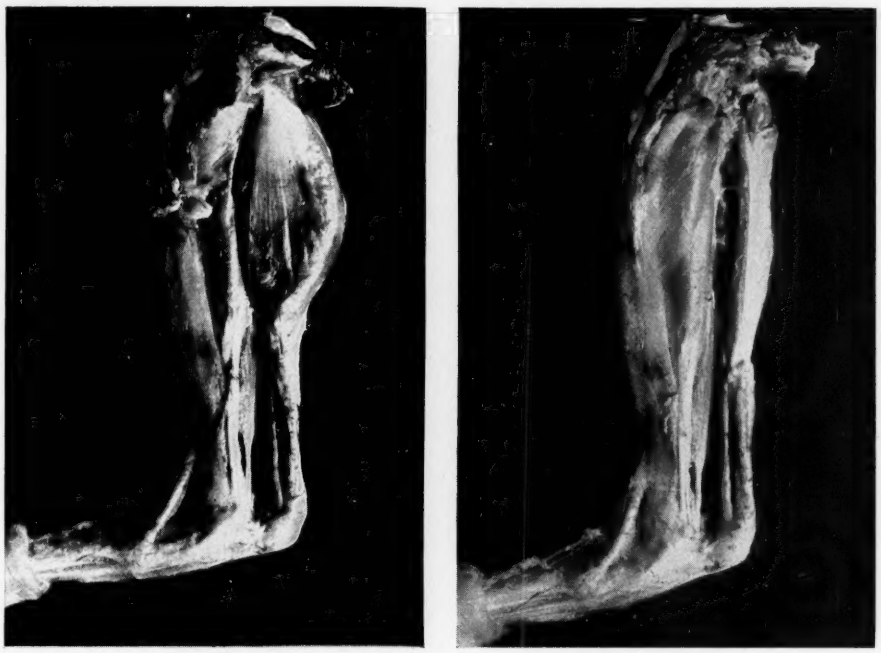


a *b*

FIG. 277.—*Experimental Cat* 3, six weeks after operation. The dissections are the same as those done on the normal cat shown in *Fig.* 276, *a* and *b*, except that only the belly of the gastrocnemius could be removed as there is no separate tendo Achillis. Gastrocnemius, plantaris, and soleus have now a common tendon.

Cat 3.—There is a complete continuity of structure between the cut ends of the tendon of the plantaris. The two heads of the gastrocnemius are markedly shortened and relaxed, and their cut ends are attached to the belly of the plantaris. They cannot have been of much assistance in raising the heel. The newly formed tendon is directly continuous with the plantaris and is proportionately longer than the original tendon. The soleus is also attached to the new tendon. The deep flexors have reunited. (*Fig.* 277.)

Cat 7.—This closely resembles the condition seen in *Cat* 3. The newly formed tendon is, however, less firm and more diffuse. The gait of this animal did not recover so completely as *Cats* 3 and 6 and this was probably due to the condition of the newly formed tendon. This less complete recovery can probably be explained by the general condition of the animal, which was rather emaciated and suffered from diarrhœa during the whole period of experiments.



a *b*

FIG. 278.—*Experimental Cat* 6. Similar to *Fig.* 277, *a* and *b*.

Cat 6.—This showed a much better anatomical result than was seen in the other animals. The new tendon could be partially divided into two parts, one formed from the gastrocnemius and a portion of the plantaris, and the other from the remainder of the plantaris and soleus. Although less marked than in the previous animals, the newly formed tendon was relatively longer than the normal and the muscle bellies had shortened. The deep flexors had reunited. (*Fig.* 278.)

In all the animals the tendons had definite sheaths within which they were freely movable.

The results of these experiments do not agree with the views of Wehner (1923). That investigator states that the ability of the newly formed tendon to function depends upon the position taken up by the joint during recovery. If this is outside the normal pose of the animal, the regenerated tendon will be too long.

On account of this the contractile power of the muscle will be diminished and there will be functional insufficiency of the tendon. In the present investigation, the pose of the limb after the operation was undoubtedly quite different from the normal of the cat. This caused a lengthening of the newly formed tendon and a shortening of the muscle, which was marked in two of the animals. This, however, did not lead to any disability, and it must be presumed that the muscle was able to function quite satisfactorily in its new position.

HISTOLOGICAL RESULTS

The tendons were removed, embedded in celloidin, and histological sections were prepared stained with hæmalum and eosin (*Fig.* 279). At the same time

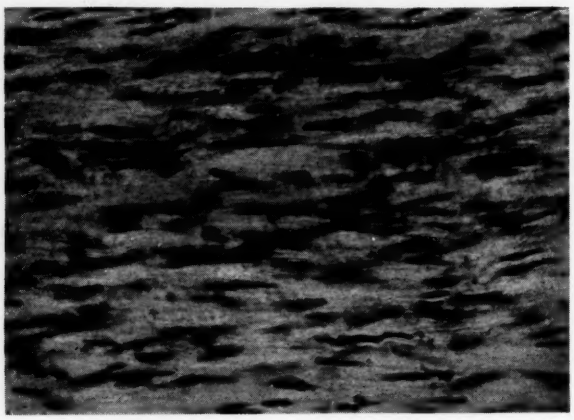


FIG. 279.—Microscopical section of regenerated tendon of cat.

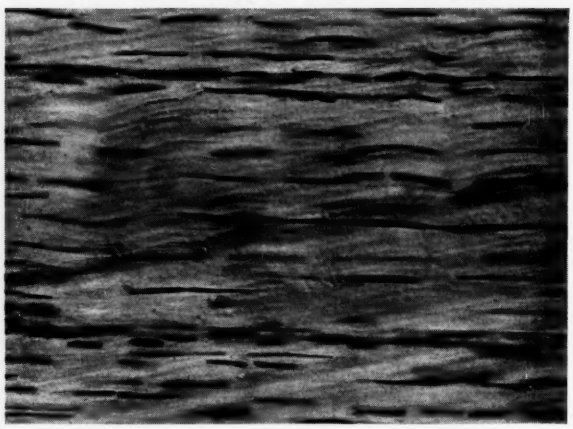


FIG. 280.—Microscopical section of normal tendon.

tendons were taken from the same region of a normal cat and similar histological preparations were made of these for purposes of comparison (*Fig.* 280).

The newly formed tissue is very definitely tendinous in appearance microscopically, but shows several features which distinguish it from the normal tendon. The fibres, though tending to be parallel, do not all run in the same direction, and they also differ from the normal as their course is rather waved instead of being in straight lines. This waviness is also seen in the direction of the cells, which are also much less compressed from side to side than in the normal tendon. Although they are arranged in rows, these are not so clearly defined as in the normal condition, neither are the rows so markedly separated from each other by the fibrous bundles, which are much narrower in the newly formed tissue.

These histological findings agree with the results obtained by the great majority of workers in this field. It is true that certain investigators, such as Narvi (1931), believe that the gap is filled with scar tissue which in no way resembles tendon, but such negative conclusions cannot be given much consideration when weighed against the large volume of positive evidence that the newly formed tissue is either tendon or a tissue which structurally resembles tendon.

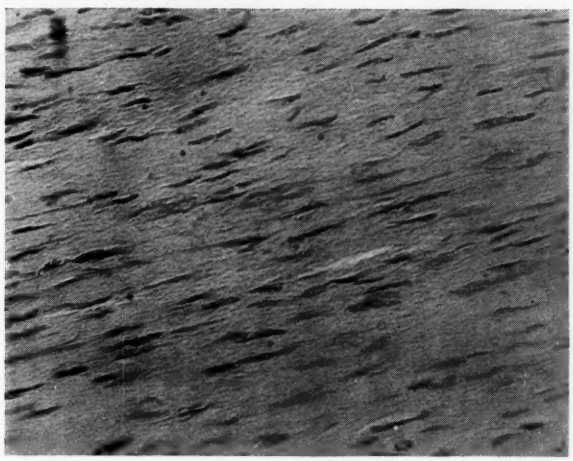


FIG. 281.—Regenerated tendon of guinea-pig, four months after operation.

The present experiments, on account of the shortness of their duration, do not materially assist in elucidating this problem as to whether the newly formed tissue is true tendon or merely a tissue which has come to resemble tendon on account of the strains and stresses to which it is subjected. The histological preparations undoubtedly resemble tendon, but, as has already been stated, they have definite characters by which they can be differentiated from ordinary tendon. It is possible that if the animals had been preserved for a longer period the distinguishing features might have disappeared. However, the author can throw some further light on this problem. A guinea-pig which underwent a similar operation to that performed upon the cats, was kept alive for four months after the operation. It will be observed that regenerated tissue in this animal (*Fig.* 281) resembles normal tendon much more closely than the same tissue in the cats which had only been kept alive for a period of six weeks. It would therefore seem probable that the tissue which reunites the ends of the tendons in the course of time approximates more and more closely to the structure of normal tendon.

SUMMARY AND CONCLUSIONS

In three cats about half an inch of the tendons of the superficial plantar flexor muscles was removed and the tendons of the deep flexors were divided. The sheaths were preserved. The animals were allowed to move about freely without further treatment. Six weeks after the operation the animals' gaits had returned to normal. Histological preparations were made from the new tissue, and this was found to have many of the characteristics of normal tendon.

I have to thank Professors Raper and Stopford for facilities to carry out this work in the Departments of Physiology and Anatomy of Manchester University.

The cost of this investigation has been met by a grant from the Manchester University Medical Research Fund.

REFERENCES

ADAMS, W., *The Reparative Process in Human Tendons*, 1860. London: John Churchill.
BLOCH and BONNET, *Congrès française de Chir.*, 1929, 547.
GAZA, GERLACH, and GISSEL, *Arch. f. klin. Chir.*, 1932, clxx, 19.
MASON and SHEARON, *Arch. of Surg.*, 1932, xxv, 615.
NARVI, E. J., *Acta chir. Scand.*, 1931, xviii, 267.
WEHNER, E., *Deut. Zeits. f. Chir.*, 1923, clxxvii, 169.

SHORT NOTES OF RARE OR OBSCURE CASES

SQUAMOUS-CELL CARCINOMA OF THE RENAL PELVIS IN A HORSESHOE KIDNEY

By W. F. NICHOLSON, Manchester

Squamous-cell carcinoma of the kidney is uncommon, but to find it associated with horseshoe kidney is sufficiently rare to justify recording this case.

The patient was a man of 51, who on admission to the Manchester Royal Infirmary gave a history of recurrent attacks of pain in the left iliac fossa, associated with hæmaturia for four months. Cystoscopy revealed blood spurting from the left ureteric orifice, and uroselectan radiography suggested the presence of a horseshoe kidney. The latter was confirmed by ascending pyelograms with sodium iodide, the radiograph showing dilatation and irregularity of the left renal pelvis

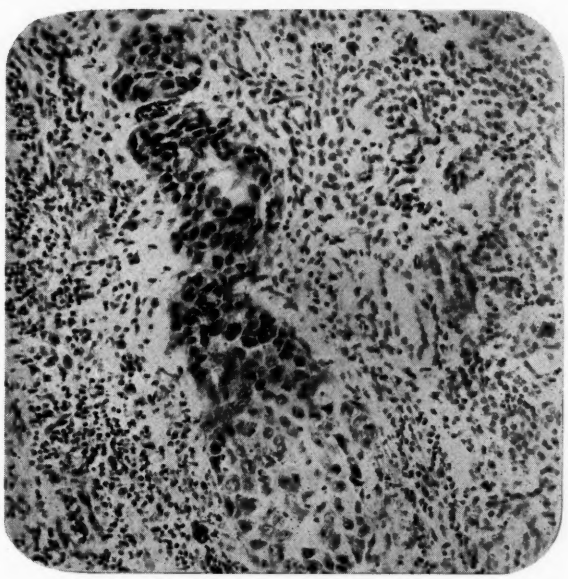


Fig. 282.—High-power view, showing growth invading kidney.

in addition. Apart from culture of *Sta. albus* from the urine, the urinary function was normal. A diagnosis of neoplasm in the left half of a horseshoe kidney was made, and in view of the repeated hæmaturia prompt exploration was advised.

Mr. Graham Bryce explored the abdomen through a left paramedian incision, the descending colon being mobilized and reflected towards the midline. The left renal pelvis was dilated, and there was hydro-ureter down to the level of the

isthmus of the horseshoe, where the ureters crossed in front of the renal substance. Nephrectomy of the left kidney was performed, the isthmus being divided at the

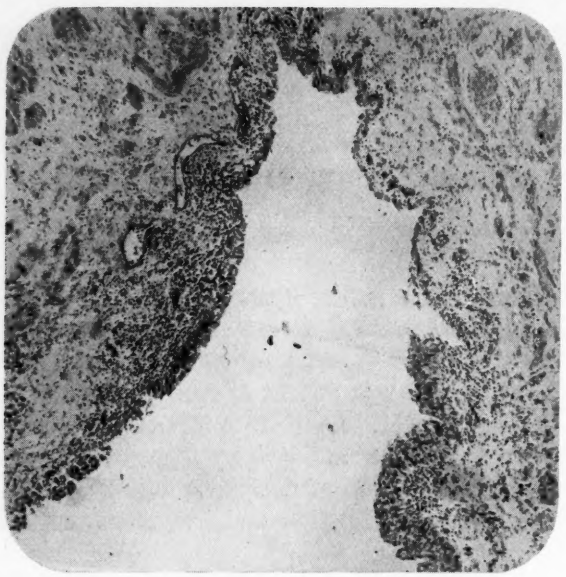


FIG. 283.—Low-power view of renal pelvis, showing proliferation of epithelium in parts and degeneration in other parts.

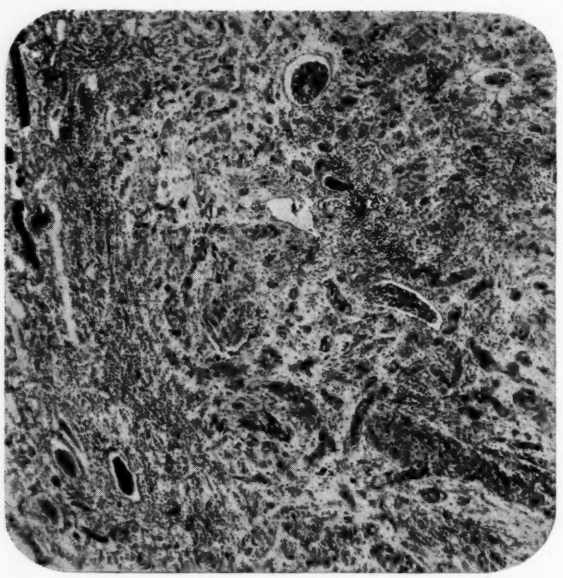


FIG. 284.—Low-power view showing renal substance invaded by growth.

lower pole of the left kidney. On naked-eye examination the left kidney was hydronephrotic with much fibrosis of the pelvis. No obvious growth could be identified, but the whole pelvis was greatly thickened.

Microscopical examination showed that this was a squamous-cell carcinoma arising in the pelvis and invading the kidney substance (*Figs.* 282–284). The patient made a good recovery from operation, but died of secondary deposits six months later.

Comment.—In a review of 68 cases of horseshoe kidney, Walters and Priestley[1] at the Mayo Clinic described only three tumours, none of them squamous carcinoma. Similarly Rathburn[2] described four neoplasms in 108 cases of horseshoe kidney, but none of them was squamous carcinoma. The microscopical sections show the lack of cell-nests which is the feature of squamous carcinoma in this region, to which Silverstone[3] has recently called attention. The pelvic epithelium has proliferated in places, but mostly is degenerate and shows signs of chronic pyelitis. Nowhere does it show definite leukoplakia, as Kutzmann[4] and Thomson-Walker[5] have described in association with these growths.

I am indebted to Mr. Graham Bryce for encouragement and permission to publish the case, and to Dr. Loveday for the sections.

REFERENCES

[1] WALTMAN WALTERS and JOHN PRIESTLEY, *Jour. of Urol.*, 1932, xxviii, 271.
[2] RATHBURN, *Ibid.*, 1924, xii, 611.
[3] MAURICE SILVERSTONE, *Brit. Jour. Surg.*, 1935, Oct., 332.
[4] KUTZMANN, *Arch. of Surg.*, 1929, xix, 871.
[5] THOMSON-WALKER, *Proc. Roy. Soc. Med.*, 1927, xx, 720.

B. WELCHII INFECTION COMPLICATING CONSERVATIVELY TREATED APPENDICEAL ABSCESS

BY STUART GORDON, TORONTO

The following case report is considered to be of sufficient interest to justify publication.

O. B., a farmer aged 50, was admitted to the Toronto General Hospital on Oct. 25, 1935. Three days previously he had first complained of abdominal discomfort. Two days prior to admission, the discomfort shifted to the right lower quadrant of the abdomen. He lost his appetite. During the following day he became nauseated and vomited. His pain became very severe and he called his doctor at midnight. Examination at 4 a.m. revealed a spare individual who did not appear ill. The lower part of the abdominal wall did not move with inspiration and expiration. There was hyperæsthesia over the right lower quadrant. The right rectus was splinted. A tender mass about the size of a lemon was palpable in the region of the cæcum. Rectal examination revealed a tender area high and to the right. His temperature was 101·8° by mouth; his leucocyte count 20,000. The urine was normal. A provisional diagnosis of appendiceal abscess was made and conservative treatment decided upon. The patient accordingly was placed in Fowler's position, continuous intravenous saline was started, and an electric cradle was placed over the abdomen. Ice chips only were allowed by mouth; no laxative, no enema, and no sedative. A close watch was kept on the pulse-rate.

Eight hours later the abdomen was soft and the patient appeared comfortable. For the next two days his condition was quite satisfactory. On Oct. 28, following

an examination by a medical student, the patient stated he definitely and suddenly became worse. His temperature rose to 102°. The abdomen during the next few hours became distended, tender wherever examined, and the heart-sounds could be detected by auscultation in the lower half of the abdomen. It was believed that the abscess had ruptured and that the patient was now suffering from a general peritonitis. Four-hourly injections of pituitrin and eserin were ordered. These were effectual. By the evening of Oct. 29 his condition had improved considerably. The abdominal tenderness had lessened markedly. There was no distension. Heart-sounds could no longer be heard over the abdomen. A large pelvic abscess was felt on rectal examination.

The patient was seen at 7 a.m. on the morning of Oct. 30 by the house surgeon. He complained of numbness in the right thigh, but examination showed nothing

FIG. 285.—Radiograph showing extensive gaseous infiltration of the upper part of the thigh.

abnormal. At 9 a.m. the patient was again seen. False emphysema was noted in Scarpa's triangle. Gas gangrene serum was given intramuscularly. By mid-afternoon the thigh was twice its normal size, there were large dark bluish blebs along its medial aspect, and gangrenous emphysema was present from inguinal ligament to knee. Gas gangrene serum was again administered, this time intravenously, and the patient taken to the anæsthetic room. Under gas-oxygen anæsthesia four incisions were made the length of the right thigh. Foul-smelling gas hissed and bubbled out behind the scalpel. The adductor muscles were completely destroyed, being replaced by a structureless dull-red mass. Four rubber tubes were pushed for varying distances into the thigh and connected with an oxygen tank. Cultures were taken. Shortly afterwards the patient died.

At post-mortem a large appendiceal abscess was found. The appendix had perforated at its base and extruded a fæcolith. A probe was passed without any difficulty into the cæcum. The lower boundary of the abscess was formed by the peritoneum overlying the iliacus muscle. An area the size of a shilling had been eroded in the peritoneum and fascia overlying the muscle. Bubbles of gas were present in the iliacus muscle. It would appear, therefore, that the infection had spread by way of the iliacus into the thigh. There was a mild general peritonitis, and a large pelvic abscess. The gaseous infiltration in the thigh is shown in *Figs.* 285, 286.

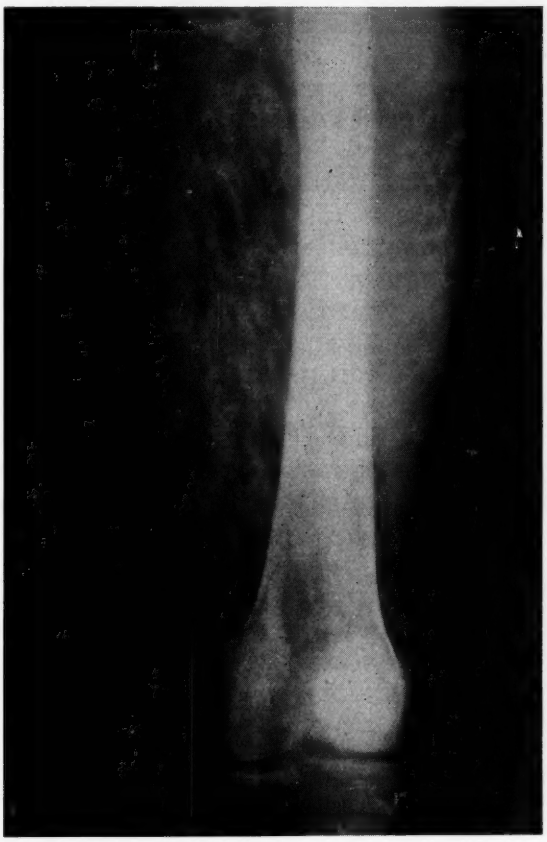


FIG. 286.—Showing the infiltration of the lower part of the thigh.

The culture taken at operation revealed *B. welchii*, as did a culture taken from the right thigh at post-mortem. Cultures of the peritoneal cavity and the pelvic and appendiceal abscesses grew a streptococcus.

Summary.—A case of appendiceal abscess, treated conservatively, which resulted in a gas gangrene infection with fatal termination, is reported. It is presumed that the organism responsible for the infection spread from cæcum to abscess, to iliacus muscle, and to thigh. The rarity of the complication, together with the fact that no operative interference had taken place prior to the development of the gas bacillus infection, are considered sufficient justification for this communication.

UMBILICAL FISTULA CAUSED BY A PATENT MECKEL'S DIVERTICULUM

By MAY RATNAYEKE

MEDICAL OFFICER IN CHARGE, LADY HAVELOCK AND LADY RIDGEWAY HOSPITAL, COLOMBO

Cases of persistent Meckel's diverticulum with external opening are sufficiently rare to warrant publication.

Meckel's diverticulum is a persistent remnant of the omphalomesenteric duct. It is represented by a mere pouch in most cases; occasionally it may extend from the ileum to the umbilicus, or float free at the distal end. In this case the diverticulum was patent and produced a fistula discharging liquid yellow fæcal matter and gas.

Fig. 287.—Showing the incision encircling the umbilical fistula.

History.—A male infant 6 weeks old was admitted to the Lady Ridgeway Hospital, Colombo, with a history of a discharge of fluid and fæculent material through a red polypoid protrusion at the umbilicus since the separation of the umbilical cord on the tenth day after birth.

Physical Examination.—The infant is well nourished. The stools are normal, one or two a day. The skin around the umbilicus is excoriated. At the umbilicus there is a protrusion of mucous membrane discharging fæculent material and gas when the child strains or when the abdomen is stroked. The child is breast-fed. Its weight is 9 lb. 5½ oz. An X-ray examination after injection of 2 c.c. of lipiodol through the fistula displayed the track of the fistula and the lipiodol outlining the coils of small intestine.

Operation.—The infant was operated on under open ether anæsthesia on Feb. 25, 1936. An incision was made around the umbilicus with its mucous protrusion (*Fig.* 287) and deepened until the peritoneum was seen encircling the diverticulum of gut. In order to deal with the diverticulum at its origin, the peritoneum was opened up about an inch

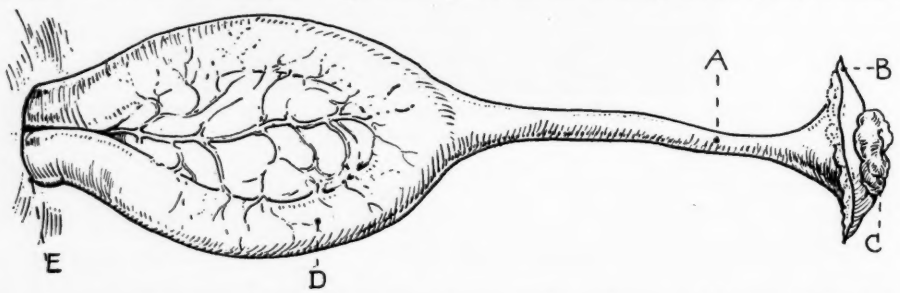


Fig. 288.—The diverticulum and the loop of gut withdrawn from the abdomen. A, Meckel's diverticulum: B, Umbilicus dissected out: C, Protrusion of mucous membrane; D, Loop of gut; E, Incision in parietes.

and the loop of intestine from which the diverticulum arose was lifted out by traction on the diverticulum (*Fig.* 288). When this was exposed it was found to be 3 in. in length, and had the appearance of a normal appendix. The base of the diverticulum was clamped, crushed, ligated, and divided, not too close to

the gut, in order to avoid narrowing of the gut lumen. The stump was not buried, but two occluding sutures partially covered its stump (*Fig.* 289). The

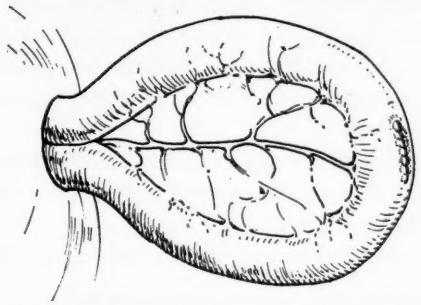


FIG. 289.—The diverticulum has been removed and the gut sutured.

intestine was returned to the abdomen. The opening in the peritoneum was closed, the rectus was approximated, and the skin edges were brought together.

The child made an uneventful recovery, and was discharged cured on the twenty-first day.

AN INACTIVE PARATHYROID TUMOUR

BY GEOFFREY KEYNES

ASSISTANT SURGEON, ST. BARTHOLOMEW'S HOSPITAL, LONDON

A LARGE number of examples of enlargement of the parathyroid glands have now been reported in surgical literature, interest in them being due not to their features as tumours in the neck, but solely to their influence on the skeleton through their internal secretion. They are indeed scarcely to be regarded as 'tumours' in the pathological sense, being rather due to enlargement of normal parathyroid bodies, without production of any abnormal tissue. Their structure is that of normal parathyroid tissue, and it is very seldom that any swelling can be detected clinically in the neck or elsewhere. Usually the presence of the parathyroid enlargement is inferred from its endocrine effects, and an exploratory operation is undertaken in the neck or mediastinum to discover its whereabouts. It may be of some interest, therefore, to describe a rare condition in which the position is reversed, an operation being undertaken to remove a large and clinically palpable parathyroid tumour which had not produced any endocrine effects whatever.

A female patient, aged 50, was referred to me recently by Dr. Hinds Howell for an opinion concerning a tumour in the neck. On the left side of the neck was a firm solid swelling, situated beneath the upper part of the sternomastoid, close to, and superficial to, the upper pole of the thyroid gland. It was not easy to feel, being mobile and deeply placed. No definite diagnosis could be made, since it was producing no symptoms; nevertheless removal seemed to be advisable on general principles.

The tumour was easily removed from the upper deep cervical region through a high collar incision, and it did not have any obvious attachment to the parotid, the thyroid, or any of the neighbouring structures.

The tumour was of irregular shape, of homogeneous consistency, with a whitish cut surface, and weighed 18 g. The microscopical section showed a solid cellular

structure resembling that of a parathyroid gland. It was, in fact, impossible to regard the tumour as being anything but a parathyroid adenoma, and this opinion was confirmed by Professor Geoffrey Hadfield, who pointed out, however, that the tumour consisted almost exclusively of the oxyphil cells usually seen in small groups in sections of normal parathyroid glands. This fact is demonstrated in the accompanying figure of a typical area made from a colour-photograph taken in Professor Hadfield's laboratory (*Fig.* 290).

Radiograms of the patient's skeleton were taken after the nature of the tumour had been established, but no abnormality was discovered. Estimation of her serum calcium was not considered worth while, since the level of this would in any case have fallen to normal immediately after the removal of an active parathyroid tumour.

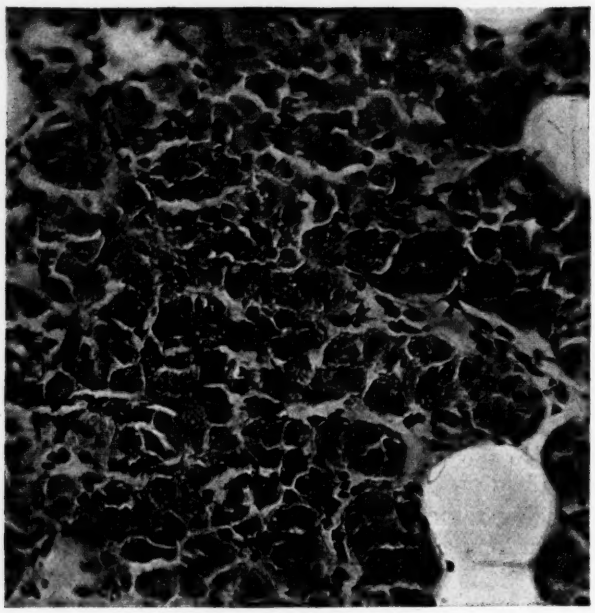


FIG. 290.—Section through tumour, showing solid cellular structure resembling parathyroid gland, but consisting almost entirely of oxyphil cells. (× 170.)

Comment.—This case seems to establish the occasional occurrence of a large parathyroid tumour in the neck which is totally inactive as regards its internal secretion. Hadfield and Rogers[1] have already recorded such a tumour, weighing 52 g., in a woman of 58 whose skeleton was normal radiologically, and report that three others have been described by Hoffheinz.[2] Professor Hadfield[3] has also made the suggestion that the lack of secretory activity in the tumour here recorded, and perhaps in others, is due to the special character of the cells composing it. He informs me that the tumour in his case mentioned above was also composed almost entirely of oxyphil cells, this feature probably indicating that they are in a senile or inactive phase. The same interpretation is to be put upon the groups of similar cells seen in the normal gland.

REFERENCES

[1] HADFIELD, G., and ROGERS, H., *Jour. Pathol. and Bacteriol.*, 1932, xxxv, 259.
[2] HOFFHEINZ, *Virchow's Arch. f. pathol. Anat.*, 1925, cclvi, 705.
[3] Personal communication.

SMALL ANGIOMA OF RENAL CALIX

By H. A. COOKSON
HON. PATHOLOGIST TO SUNDERLAND ROYAL INFIRMARY

A FEW notes on a case of hæmaturia are given, because the case illustrates how in the past it would have been grouped under the heading of 'renal hæmophilia' or 'essential hæmaturia'.

H. P., a single woman, aged 36 years, a shop assistant, was admitted to the Royal Infirmary, Sunderland, on Feb. 5, 1936. She complained of blood in the urine for the last four months. The urine is stated to have been bright-red in the morning but became brown for the rest of the day. There was no frequency and no pain ordinarily, but she had had slight pain in the right groin during her periods for the last few months.

For about five years she has vomited during the two days preceding menstruation. Nothing was found on abdominal examination, and owing to the fact that she was menstruating and had tonsillitis she was discharged on Feb. 8.

On Feb. 25 she was re-admitted. The bladder was found normal at cystoscopy on Feb. 27, but bright-red urine was seen coming from the right ureter and normal urine from the left. The pyelogram was normal on both sides. Examination of ureteral catheter specimens showed normal urine from the left and red blood-cells only from the right. The catheter specimen of bladder urine was examined on Feb. 7, when it was found to have a few pus cells in addition to the above. The blood-count on March 16 was: hæmoglobin 56 per cent, red blood-cells 3,660,000 per c.mm., colour index 0.78, no white-cell abnormality. Operation was refused.

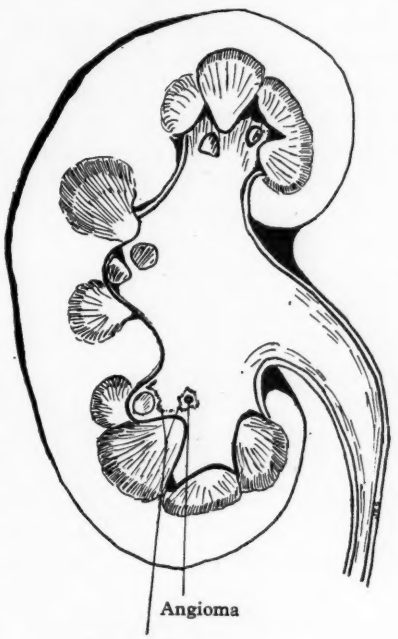


FIG. 291.—Diagrammatic view of the pelvis of the kidney to show the site of the angioma.

She was again admitted on April 3. There was no hæmaturia for two weeks. The urine was examined on April 6, when a few pus cells were present, but no pathogenic organisms. The right kidney was removed on the same day, when the fat over the pelvis was seen to be very hard and adherent, otherwise the kidney looked normal. She was discharged on April 21.

REPORT ON KIDNEY.—The kidney as a whole presented no macroscopic abnormality, but when the renal pelvis was inspected it showed some swelling of the mucous membrane, and there was a small uratic deposit in one of the calices. When this deposit was cleared away there was seen a minute red nodule about the size

of a pin's head and evidence of recent bleeding therefrom (*Fig.* 291). Microscopical sections through the nodule showed what appeared to be an angioma (*Figs.* 292, 293).

FIG. 292.—Microscopical section through the angioma. (× 120.)

FIG. 293.—The same, more highly magnified. (× 275.)

I have to thank Mr. H. Ross, Hon. Surgeon to Sunderland Royal Infirmary, under whose care this patient was, for the clinical notes of the case.

DIFFUSE CARCINOMATOUS INFILTRATION OF THE BONES OF THE FACE AND SKULL SIMULATING LEONTIASIS OSSEA

By ROBIN PILCHER

FIRST ASSISTANT IN THE SURGICAL UNIT, UNIVERSITY COLLEGE HOSPITAL

WITH NOTES ON THE X-RAY EXAMINATION

By GWEN HILTON

ASSISTANT RADIOLOGIST, UNIVERSITY COLLEGE HOSPITAL

CLINICAL NOTES.—W. S., male, aged 56, was admitted to University College Hospital on Sept. 12, 1935, complaining of a painful swelling of the right side of the face for a year and a purulent discharge from the right nostril for a week. There was a history of treated syphilis since 1904, and in 1913 there were enlarged glands in the neck, said to have been tuberculous. There had been several attacks of ulceration of the throat, the last in 1922. A year before admission the teeth had been extracted, and according to the patient the swelling of the face first appeared shortly after this operation. The patient was sent to the Hospital by Mr. E. A. Peters, who regarded the condition as "malignant infiltration superimposed on syphilitic scarring".

The patient's general condition was poor, and he was in constant pain. The appearance of the face is shown in *Fig.* 294. The œdema of the eyelids was at first more extensive, but subsided during the first week in hospital. The skin around the right nostril and the right angle of the mouth was anæsthetic, but there was no facial weakness. The mouth was edentulous. There was intense leucoplakia of all parts of its mucous membrane, the change being most advanced in the palate and fauces, which were contracted and immobile. The concavity of the palate was almost obliterated by swelling, and the upper alveolus was uniformly expanded. No change was observed in the shape of the lower alveolus. On the right posterior end of the upper alveolus was a patch of superficial ulceration, but elsewhere the surface of the dense white mucous membrane was intact. The right side of the nose was blocked, and mucopus was running from the right nostril and down the nasopharynx. In the left posterior triangle two soft glands were palpable, and in the right posterior triangle was a small scar. The swelling of the face was apparently due partly to œdema of the soft tissues, but there was also enlargement of the underlying bone. Some thickening of the skull was palpable in the right frontal and temporal regions, the surface of the bone being slightly nodular. No clinical evidence of carcinoma was found in the mouth or nose. There was a slight secondary anæmia, and the Wassermann reaction of the blood was positive.

Anti-syphilitic treatment was started, and there was an immediate slight improvement which was not maintained. A piece of the right upper alveolus was excised for histological examination. The biopsy wound did not heal, but took on the appearance of a carcinomatous ulcer. The general condition deteriorated rapidly, and the patient died five weeks after admission.

X-RAY EXAMINATION (*Figs.* 295, 296).—Pathological changes are seen in the whole of the radiograph of the skull and the mandible, but are most marked in the maxillary and malar bones. The lesions in the vault are purely destructive, no new bone formation being seen. They appear as irregular osteoporotic areas scattered throughout the bones, giving the whole a worm-eaten appearance. They are chiefly localized in the frontal bones, but they are also present to a less extent

FIG. 294.—Appearance of the patient on admission.

in the parietal bones and in the squama of the temporal bones. Very few lesions are seen in the occipital bones. The inner and outer tables are not thickened anywhere and have smooth margins except in the frontal bone, where the outer table appears to be rarefied in several places. The floor of the anterior fossa is eroded, and the boundaries of the sella turcica are barely visible. The frontal, ethmoidal, and sphenoidal sinuses are obscured and their margins are impossible to define.

The changes in the bones of the face appear to be somewhat different. All normal contours have been lost. The bones have been replaced by a shapeless mass of spongy appearance with but slight calcification. This is so lacking in density that an antero-posterior view almost suggests that the lower part of the front of the skull is missing. The cervical spine is clearly visible through it. No indication of the position of the maxillary antra can be detected. The orbital fossæ are partially filled with the structureless material.

Osteoporotic areas are present in both mandibles, particularly in the ascending rami.

The total appearances in the vault resemble those of metastatic carcinoma, but the appearances in the face bones, which are the dominating features of the

FIG. 295.—Radiograph of the skull and mandible, lateral view.

FIG. 296.—Radiograph of the skull and mandible, antero-posterior view.

radiograph, are similar to those described by various authors as one of the types of leontiasis ossia.

POST-MORTEM EXAMINATION.—A complete post-mortem examination was made, and no evidence of malignant disease except that in the mouth and the bones of the face and skull was found. The ulcer in the mouth had extended, and involved the right half of the palate. The upper alveolus, especially on the right side, was thickened and softened. A piece of the right maxilla including the alveolus and the floor of the antrum was easily cut out with a knife. There appeared to be no infiltration of the soft tissues of the cheek, and the cavity of the antrum was not obliterated. When the scalp was turned down it was again noted that the soft tissues were free of macroscopic signs of growth. The surface of the skull in the right frontal and temporal regions was nodular. The right orbit was explored and no growth was found in it. There were thickening and softening of the great

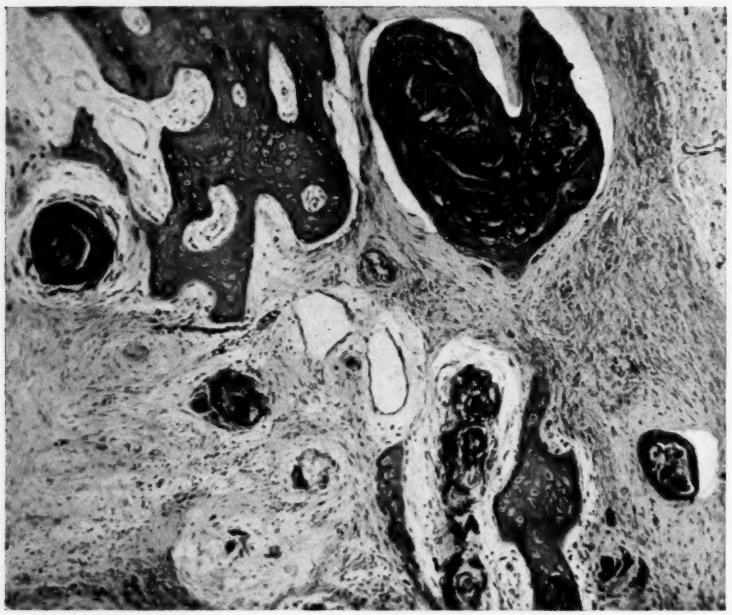


FIG. 297.—Microscopical section of maxilla. Epithelial pearls in fibrous stroma. In other parts of this section the stroma is scanty. (× 84.)

FIG. 298.—Microscopical section of frontal bone. Islets of carcinoma surrounded by fibrous tissue. (× 84.)

wing of the sphenoid, but it could not be cut as easily as the maxilla. In addition to the maxilla, pieces of bone were removed for histological examination from the right sphenoid, temporal, and frontal bones. The striking feature of the malignant process was its apparent localization to bone.

Histology.—The appearances of the biopsy and post-mortem specimens are similar. In all of them there is invasion and destruction of bone by well-differentiated squamous carcinoma with cell-nest formation. Where the growth has invaded the bone there is a fibrous-tissue reaction and some new bone formation (*Figs.* 297, 298). Except in the maxilla the fibrous tissue is in excess of the carcinoma, but in none of the sections examined was fibrous-tissue replacement of bone found without carcinoma. The part of the antrum included in the section of maxilla has a normal columnar epithelial lining.

Comment.—On admission this was thought to be a case of leontiasis ossea. Carcinoma was not suspected until biopsy was performed. The site of origin of the carcinoma was not discovered, but was probably one of the tooth sockets of the upper jaw. Before the biopsy there was nothing in the mouth to suggest carcinoma, and at post-mortem the cavity of the antrum was not obliterated and its lining was found to be normal columnar epithelium. When the result of the biopsy was known there was still doubt as to the nature of the diffuse change seen in the radiographs. It was thought that there might be two conditions present, carcinoma and osteitis fibrosa, but no evidence of the latter was found post mortem. The unusual feature of the case is the local spread of carcinoma in the bones rather than in the soft tissues, which showed no macroscopic involvement at post-mortem.

EXTREME BENIGN ENLARGEMENT OF THE PROSTATE

By J. McFADZEAN
HONORARY SURGEON, MORECAMBE AND HEYSHAM HOSPITAL
AND W. E. COOKE
PATHOLOGIST, ROYAL INFIRMARY, WIGAN

From time to time prostatic tumours are reported on account of their size. The remarkable dimensions and weight of the prostate in the present case may not constitute a record, but it is unique in our experience and in the experience of many surgeons and pathologists who have seen it.

The patient, aged 71 years, was admitted to hospital for acute retention of urine. An attempt to pass a soft rubber catheter had been made at home but had failed on account of excessive hæmorrhage. A suprapubic cystostomy was performed immediately and a large-bore de Pezzer's catheter inserted, the bladder wall first being pierced with a trocar whose cannula was just large enough to carry the stretched catheter. The urine was released at the rate of 2 oz. every hour. Drainage was continued for a fortnight, when another attempt was made to pass a catheter per urethram. This again resulted in copious hæmorrhage.

The non-protein nitrogen was 35·5 mg. per 100 c.c. of blood. Suprapubic prostatectomy was decided upon and performed under a spinal anæsthetic. On

opening the bladder the prostate was found to occupy almost the whole of the cavity. Enucleation was difficult on account of the large size of the growth, the upper surface of which came in contact with the knuckles and prevented the base of the gland being reached with the finger. (We may mention that J. McF. has exceptionally long fingers.) Finally the gland was removed by a process of fragmentation and with it two horned concretions. The patient made an uneventful recovery.

The pieces of gland were weighed immediately after the operation, and turned the scale at 1 lb. 6½ oz. The larger pieces were sutured together to obtain a photographic record. Some idea of the size will be gained from the photograph (*Fig.* 299), but large portions are missing. The tumour, as seen in the photograph,

FIG. 299.—Photograph showing the larger pieces of the removed prostate sutured together to give an indication of the extraordinary size of the tumour. (× ⅓.)

after being in 10 per cent formalin for two months, measured 6 in. by 5¼ in. by 4 in. in thickness. Many of the small rounded masses seen in the photograph were attached to the main body of the tumour by narrow pedicles and became readily detached from it.

HISTOLOGY.—All the tissues of the prostate subscribe to the enlargement of the gland and although one might be inclined to think the glandular elements preponderate and term the condition an adenoma, examination of many sections shows increase in the fibrous and muscular elements to an equal extent. Perhaps the correct category to place the tumour would be in the simple senile nodular hypertrophy class as suggested by Kettle.[1]

REFERENCE

[1] KETTLE, E. H., *The Pathology of Tumours*, 2nd ed., 252. London.

REVIEWS AND NOTICES OF BOOKS

A Textbook of Surgery. By American Authors. Edited by FREDERICK CHRISTOPHER, B.S., M.D., F.A.C.S., Associate Professor of Surgery at Northwestern University Medical School, etc. Royal 8vo. Pp. 1608+xix, with 729 illustrations. 1936. Philadelphia and London: W. B. Saunders Co. 42s.

THIS *Textbook of Surgery*, in one volume, is unique inasmuch as the contributors include surgeons of the highest distinction in America and each branch of surgery is dealt with by a recognized specialist—such names as Adson, Smith-Petersen, Balfour, Judd, and Evarts Graham may be mentioned.

The book is designed for students, and, although it would be rather heavy reading for such in the early stages of their careers, it should be of great value both to those just about to qualify and to post-graduates. As is natural in such a work there is some inequality in the sections: for example, those dealing with the Breast, Thorax, and Abdomen are admirable, whereas Tuberculosis of Joints is dealt with very briefly and in a manner which gives little help to the student.

There are valuable sections on Roentgenology and Aseptic Surgical Technic, and on such important matters as the management of the surgical diabetic patient and the care of patients after operation.

The volume is beautifully printed in clear type, and the illustrations, which are very numerous, are on the whole admirable.

A single volume text-book of this type has been badly needed, and Dr. Christopher's great work should amply fill this want.

The Operations of Surgery. By R. P. ROWLANDS, M.S. (Lond.), F.R.C.S., late Surgeon to Guy's Hospital, etc.; and PHILIP TURNER, B.Sc., M.S. (Lond.), F.R.C.S., Consulting Surgeon to Guy's Hospital, etc. Eighth edition. Volume I: The Upper Extremity. The Head and Neck. The Thorax. The Lower Extremity. The Vertebral Column. Royal 8vo. Pp. 1405 + x, with 435 illustrations (38 in colour). 1936. London: J. & A. Churchill Ltd. 36s. net.

THIS book is the direct descendant of Jacobson's *Operations of Surgery*, a volume which attained a unique place in surgical literature. In its subsequent editions it has maintained the characters which led to its high repute. It has always been a reliable guide to the younger practising surgeon, informing him what it is possible to achieve under average circumstances, warning him of dangers and accidents which lurk unsuspected, and acquainting him with the results which in the end may ensue.

The absolute dependability of the advice in its pages, the freedom from exaggeration, the balanced judgement of its presentation, were what made it of such unusual value to the junior, and even to the senior, surgeon. Mr. Turner, in bringing out this new edition, has kept closely to the ideals of its predecessors. Mr. R. P. Rowlands, before his death, had prepared much material for this edition, but those sections which he left uncompleted have been placed in the hands of Mr. W. H. Ogilvie, Mr. Grant Massie, and Mr. A. R. Thomson, whilst the gynæcology has been largely re-written by Mr. G. F. Gibbard. Capable as these hands are we cannot but be aware of the danger in multiple authorship of the book losing some of its distinctive character, in which its real value lies. One hesitates to accept it as inevitable that modern specialization should make multiple authorship necessary. However, the book does not seem to have suffered much in this respect in *Volume I*. It is still the safe guide for the junior surgeon, pleasantly written and excellently illustrated. All the usual operations performed by the general surgeon are well and clearly described, and there

are accounts of some useful procedures, such as Hey Groves's method for recurrent dislocation of the shoulder, which are rarely found elsewhere. A few not very important criticisms may be made. In the treatment of trigeminal neuralgia only one route for reaching the Gasserian ganglion for injection is mentioned; there is a long description of removal of the ganglion, whilst the usual division of the root is relegated to small print; and no account of the intracranial operation of division through the occipital region is given. Facial-accessory anastomosis is surely an operation which might have been omitted, and so perhaps is Lane's operation for cleft palate. The description of removal of a part of the lung is poor, and we should have liked to see more details given of how to perform Lorenz's useful bifurcation operation. In *Fig.* 125 the artist has depicted the humerus with the head pointing the wrong way.

We have been led to expect such a high standard in this book that a reviewer is apt to exalt minor blemishes to the position of subjects for serious criticism. There is in reality very little matter of the latter nature to be found, and the book remains one of the best guides to operative surgery in the English language. The author is to be heartily congratulated on the publication of this, the eighth and best, edition which has yet appeared.

Emergency Surgery. By HAMILTON BAILEY, F.R.C.S., Surgeon, Royal Northern Hospital, London, etc. Second edition. Demy 8vo. Pp. 842 + x, with 812 illustrations. 1936. Bristol: John Wright & Sons Ltd. 50s. net.

THE first edition of this text-book was issued in two volumes, the first of which was reviewed in this JOURNAL in April, 1931, and the second in April, 1932; in this, the second edition, these have been combined into one volume, the total number of pages being increased from 795 to 842. Certain portions have been re-written and the whole thoroughly revised. Mr. Eric Watson-Williams is again responsible for the sections upon the nose, ear, and larynx, and upon intracranial suppuration, while Mr. Humphrey Neame deals with the eye and orbit.

The very favourable opinion we expressed of the first edition has been decidedly enhanced, and we can recommend this work not only to the 'comparatively isolated' and occasional surgeon for whom, primarily, it was written, but also to others of much wider experience. There are such excellent accounts not only of the emergency operations themselves, but of their complications and the best measures of meeting them, that it is obvious that the author has had an exceptionally extensive and varied practical acquaintance with the surgery of emergencies.

The book is splendidly illustrated, clearly printed on very good paper, and thoroughly indexed.

Neurological Surgery. By LOYAL DAVIS, M.S., M.D., Ph.D., D.Sc. (Hon.), Professor of Surgery and Chairman of the Division of Surgery, Northwestern University Medical School, Chicago, Illinois. $5\frac{3}{4} \times 9\frac{1}{4}$ in. Pp. 429, with 172 illustrations and 2 plates. 1936. London: Henry Kimpton. 28s. net.

THE field of neurological surgery has expanded considerably during the last twenty years, and yet there is still a feeling amongst some medical men that the surgery of the brain is practically useless. It is because of this attitude that Loyal Davis was prompted to write this book on neuro-surgery. The book is not written for the neuro-surgeon but for the general surgeon who may have to undertake the surgery of the brain; it will also be of use to the general practitioner in convincing him that success often follows surgical operations on the central nervous system.

The first chapter is devoted to a lucid account of the way in which a neurological diagnosis may be obtained. Cranio-cerebral injuries are carefully considered, and the modern tendency of non-interference, unless there are definite signs, is stressed. The largest chapter in the book is devoted to intracranial tumours, and a well-balanced account of the various types is given. The illustrations on the whole are excellent, especially the micro-photographs. Intracranial abscesses receive scant attention. The spinal cord, the peripheral nerves, and the autonomic nervous system are dealt with in separate chapters.

Although the literature dealing with neurological surgery is becoming voluminous, yet we feel that there is room for this book, especially for senior students who want a practical monograph on the subject. It is a great pity that no bibliography is incorporated in the book; a few scattered references at the foot of some pages is not quite in keeping with a monograph dealing with a special subject.

Cystoscopy and Urography. By JAS. B. MACALPINE, F.R.C.S., Hon. Surgeon and Surgeon in Charge of the Genito-urinary Department, Salford Royal Hospital, Manchester. Second edition. Large 8vo. Pp. 478 + xv, with 297 illustrations and 14 coloured plates. Bristol: John Wright & Sons Ltd. 30s. net.

THE first edition of this book appeared nine years ago: at that time we ventured to predict a great success for it as one of the best surgical monographs which have been published during the last thirty years.

The rapidly increasing part played by urography since the introduction of uroselectan has induced the author to alter the title of his book from *Cystoscopy* to the present *Cystoscopy and Urography*, and has made it necessary for him to remodel some chapters and to add an entirely new section.

The book is admirably turned out; it is light to hold and of convenient size; the printing is clear and easy to read; the many illustrations are strictly relevant to the text, and both these and the coloured plates are of real artistic merit. Last, but not least, the book is written in such a clear and concise style that it is a pleasure to read, and one feels that the author is a master of his subject; he has not only had an extensive experience but has read widely and thought deeply about genito-urinary surgery.

The cystoscopic pictures of the bladder are really superb, and their value is much increased by the simple device of giving a linear indication in the margin of the direction in which the beak of the cystoscope was pointing; this is an improvement that will be greatly appreciated by all cystoscopists.

The sections on perurethral prostatectomy, on pelvic resorption, and on urography are all excellent, and are good examples of the author's balanced judgement.

A new chapter is devoted to the consideration of that very important subject—the congenital abnormalities of the kidney and ureter: it is clear and thoroughly up to date, the one exception that might be taken to it is that in the description of hypoplasia of the kidney no mention is made of the absence of the usual number of papillæ; unless this deficiency is taken into account, the condition is difficult, or impossible, to distinguish from atrophy.

A most interesting chapter is devoted to what is often called Schramm's phenomenon, though wrongly according to Macalpine. This is a condition, well recognized by all cystoscopists, in which the posterior wall of the prostatic urethra and the verumontanum can be clearly seen on withdrawing the cystoscope from the bladder; it is met with in men, and is nearly always associated with disease of the nervous system. The author has christened it 'funnel-neck deformity of the bladder', and he goes so far as to say that no cystoscopy in the male should be considered complete until the cystoscope has been withdrawn into the prostatic urethra; this is indicated even more imperatively in the presence of signs of obstruction to micturition and of trabeculation of the bladder. That it is a sign of real value is proved by the records of cases in which the discovery of this phenomenon has antedated the finding of other signs of nervous disease. Whilst there can be no doubt of the existence of this deformity, its mechanism is by no means clear; cystograms taken in such cases usually reveal no leakage of urine into the dilated prostatic urethra, and it has been suggested that the weight of the beak of the cystoscope may depress the posterior wall of the internal meatus.

In the section on Urography the author makes a suggestion that may prove of considerable value in the future; instead of estimating the amount of residual urine by catheterizing a case of enlarged prostate, he thinks it would be feasible to do so by taking a skiagram of the bladder after the injection of uroselectan—of course, after the patient has tried to empty his bladder. This, if successful, may save much heartburning to the surgeon and may add many years to the patient's life.

Another ingenious suggestion is that of giving a spinal anæsthetic to the patient suffering from a stone in the ureter; this might induce a relaxation of the ureteric muscle analogous to the relaxation obtained in cases of intestinal obstruction.

There is a good index and a delightful absence of misprints; we warmly recommend this monograph to our readers and we offer our congratulations to the author, the artist, and the publishers; they have produced a book which is a credit to British surgery.

A Handbook of Urology for Students and Practitioners. By VERNON PENNELL, M.A., M.B., B.Chir. (Cantab.), F.R.C.S. (Eng.), Hon. Surgeon and Surgeon with Charge of Urological Department, Addenbrooke's Hospital, Cambridge; etc. Cr. 8vo. Pp. 224 + viii, with 34 illustrations. 1936. London: Cambridge University Press. 7s. 6d.

IN this work the author's aim is to give a short and concise account of urinary diseases, with their method of investigation and treatment. He is a urologist of some experience, for he worked with Mr. Canny Ryall at the All Saints' Hospital, London, and is now in charge of the Urological Department at Addenbrooke's Hospital, Cambridge.

Mr. Pennell has a light touch and the gift of making his subject interesting; the sections on growths of the bladder and on the treatment of the enlarged prostate are very good, but the pleasure derived from reading this book is spoilt by defects which, if minor, are undoubtedly too numerous.

To give a few instances: in the section on tests of renal efficiency, phenol red is recommended and stated to be the substance most commonly used for this purpose—though we doubt whether this is so, even in the United States where it originated—and yet, after reading this, we are astonished to find that this test is never mentioned again; indeed, whenever a test of renal function is indicated, the author invariably uses indigo-carmine.

In the discussion on the treatment of pyelitis it is said that a ketogenic diet may be worthy of a trial, "although as a rule it is not well borne"; with this we agree, but are not a little surprised to find that no mention is made of mandelic acid; we are still more surprised to find, in the appendix of drugs at the end of the book, a prescription for administering this new and efficacious drug.

We consider his assertion that the development of an intestino-vesical fistula is generally due to malignant disease to be inaccurate; nearly fifty years ago Harrison Cripps wrote an admirable monograph on this very subject, in which he pointed out that a commoner cause was inflammation of the colon; this has been abundantly confirmed since, and most, if not quite all, urologists would agree that the majority of such cases of pneumaturia are due to diverticulitis.

Though Mr. Pennell to some extent disarms criticism by confessing that he is acutely conscious of the deficiencies in his book, we feel that he should have taken more care to exclude any inaccuracies in a book destined for students.

Again, we think that no work on urology can be considered up to date which advises for the removal of a stone from the lower end of the ureter a curved incision similar to that for the extraperitoneal ligature of the common iliac artery; surely, surgeons agree that the median subumbilical incision is infinitely preferable—this is not even mentioned.

The author's grammar and spelling are sometimes strikingly unconventional, or perhaps it would be more charitable to assume that he had no chance of reading over the proof sheets. We cannot congratulate him on his coloured plates; the cystoscopic view of a papilloma of the bladder (*Fig.* 23) is very much below the standard of modern cystoscopic atlases.

The Principles and Practice of Urology. By FRANK HINMAN, A.B., M.D., Clinical Professor of Urology at the University of California Medical School. Large 8vo. Pp. 1111, with 513 illustrations. 1935. London and Philadelphia: W. B. Saunders Company. 45s. net.

AFTER skimming over the eleven hundred pages of this vast work (no inconsiderable task: it would take many months to read it through as carefully as it deserves), two adjectives rise instinctively to the surface; they are *astounding* and *encyclopædic*.

Dr. Frank Hinman is well known on this side of the Atlantic for his always interesting and often highly original work on several subjects; to mention only two—his researches on

experimental hydronephrosis and renal counterbalance. In addition to this, he gives an autobibliography of well over one hundred articles, and it seems to us astounding that he has found time to collect all the information set out in this volume.

The work is encyclopædic, for in it will be found not only an account of genito-urinary surgery but sections on the anatomy and physiology of the organs concerned, their development and their evolution from the amœba up to man. In addition to all this, there are full accounts of the various methods of examination of these organs.

The author deserves the greatest credit for his industry, for he has not merely transposed the work of others, but he has assimilated this material and made it very definitely his own.

It is obvious that Dr. Hinman is an indefatigable collector, and this volume must take its place in the library of every urologist if only for the numerous and excellent illustrations and the many rare and curious cases he has gathered together.

Naturally, the best sections are those on subjects at which he has worked: pyelovenous backflow, hydronephrosis, and renal counterbalance; the last is particularly convincing, and, in our opinion, explains the pessimism of the French urologists as to the effect of plastic operations on the ureter on renal function.

The work has one obvious defect: so much attention is devoted to pathology and treatment that diagnosis sometimes suffers a partial eclipse. The author has been so anxious to make his book include every possible scrap of information available that the effect is occasionally rather overwhelming; one sighs for the clinical pictures drawn by the older authors—they were more artistic if less complete.

We are surprised to find in the article on tuberculosis of the kidney that no mention is made of the fact that in the female the genital organs escape infection, in such marked contrast to the course of the disease in the male.

Nor does he refer to the possibility of feeling the thickened, tuberculous ureter through the vagina or the rectum; this is a very valuable physical sign, for it can be detected by the general practitioner; we cannot find any reference to this method of diagnosing a stone in the lower end of the ureter.

An even more surprising omission is that of any description of Schramm's phenomenon —funnel-neck deformity of the bladder; particularly as there is an otherwise excellent discussion on the pathology of the bladder in diseases of the nervous system.

We point out these defects in no spirit of hostile criticism but to enable Dr. Hinman to rectify them in his second edition, which will surely be called for later.

Personally, we should omit the diagrams in any future edition; whilst fully agreeing with the author as to the value of diagrams in teaching, we look on them as useful chiefly for simplifying a subject; the diagrams in this volume are so complicated that it is quite impossible to understand them.

We heartily commend this work to our readers, but we consider it suitable only for surgeons who wish to keep it for reference; we think that the student and the general practitioner would get an altogether erroneous impression from it of the diagnosis of genito-urinary diasease.

La Pratique Chirurgicale Illustrée. Fascicule XX. Large 8vo. Pp. 259, with 219 illustrations. 1936. Paris: G. Doin et Cie. Fr. 70.

IN this volume Victor Pauchet writes on gastrectomy for duodenal ulcer and partial gastrectomy for large ulcers of the stomach, in association with Gabriel Luquet; on the cure of transverse colostomy by an operation entitled ileo-colo-rectostomy; and on common duct obstruction, in association with Dr. P. L. Gac.

The remaining articles are by various writers on operations for cleft palate, œsophageal diverticula, sublingual cyst, extravasation of urine, cancer of the urethra, cystotomy, and a new and ingenious type of Einhorn tube designed to prevent rotation in the stomach before passage into the duodenum.

The excellent illustrations of S. Dupret enable the reader to follow the details of the operations with only an occasional reference to the text, and the same high standard of the previous volumes has been maintained.

The gastric and duodenal operations here described have been presented in previous volumes with minor modifications and leave nothing to be desired.

The method described to repair the continuity of the intestinal tract after a colostomy on the left side of the transverse colon is very ingenious and was described by Pauchet at the subsection of Proctology at the Royal Society of Medicine some years ago. In the case here described a colostomy had been performed some years before for ulcerative colitis, which had produced an extensive stricture of the descending colon.

The article on the surgery of the common duct when obstructed is excellent and very well illustrated.

At the end of the volume there is an index relating to the twenty volumes now published.

Orthopædic Surgery. By WALTER MERCER, M.B., Ch.B., F.R.C.S.(Edin.), F.R.S.(Edin.), Assistant Surgeon, Royal Infirmary, Edinburgh, etc. With a Foreword by JOHN FRASER, *M.C.*, M.D., Ch.M., F.R.C.S.E., Regius Professor of Clinical Surgery in the University of Edinburgh. Second edition. Medium 8vo. Pp. 906 + xi, with 408 illustrations. 1936. London: Edward Arnold & Co. 40s. net.

THE appearance of a second edition of this work within four years of its first publication indicates that it has been appreciated, and the enlargement of the volume by two hundred pages and the extensive revision shows that the author has been industrious and anxious to perfect it and bring it up to date. In this he has been so successful that it may now be considered to be one of the most complete general accounts of orthopædic surgery to be found in the English language. The book is suitable for students, for those reading for higher examinations, and as a work of reference.

Studies on the Healing of Fractures with Special Reference to the Significance of the Vitamin Content of the Diet. By JOHN HERTZ, M.D., Assistant Surgeon, Department C, Surgical University Hospital, Copenhagen. Super royal 8vo. Pp. 286, with 82 illustrations. 1936. Copenhagen: Levin & Munksgaard. (London: Oxford University Press.) Kr. 15.

DR. HERTZ has made a review of the literature and carried out an extensive series of experiments upon animals, testing the effects of deficiency in the various vitamins upon both the inflammatory reaction which follows the trauma immediately and upon the later stages of healing.

The experiments are well presented and very beautifully illustrated. In one of the earlier chapters the author adopts the Hansen-Häggqvist syncytial theory of cellular growth in osseous tissues. It is somewhat remarkable that in an otherwise very complete bibliography references to these two authors are omitted.

Treatment of Fractures in General Practice. By W. H. OGILVIE, M.D., M.Ch., F.R.C.S. Second edition. F'cap 8vo. In two volumes. Pp. 180 + viii, with 37 illustrations. 1936. London: John Bale, Sons & Danielsson Ltd. 2s. 6d. each net.

ONE of a series of small monographs giving a compact synopsis of the treatment of fractures. The detail is scarcely sufficient to enable the reader to treat any but the simplest fracture himself, but it is sufficient for revision by students before examination or for practitioners.

The Foot. By NORMAN C. LAKE, M.D., M.S. (Lond.), F.R.C.S., Senior Surgeon and Lecturer on Surgery, Charing Cross Hospital. Large 8vo. Pp. 330 + vii, with 95 illustrations. 1935. London: Baillière, Tindall & Cox. 12s. 6d. net.

MR. LAKE has written an account of the normal foot, its evolution and development, functions, and minor variations and abnormalities. He does not include talipes or paralytic deformities, and he gives only a very brief account of injuries. In the preface he calls attention to the fact that trivial lesions of the feet cause much disability and receive scant attention in medical teaching, a complaint that is perhaps less true now that students are obliged to receive instruction in orthopædics. But this book certainly serves to fill a gap, and gives much information that is useful to the medical student and practitioner. It is also written so as to appeal to the chiropodist and masseuse.

In general the matter is simply expressed though adequate; but when operative measures are mentioned the advice given is apt to be tentative and uncertain, a matter of some importance in that the general practitioner or the masseuse or chiropodist is left with the feeling

that operations on hammer-toes or bunions cannot be safely suggested. Another point of criticism is that in a work which deals with the foot largely from the point of view of function, one might expect to find more detail of exercises for re-education in proper methods of standing and walking.

Le Cancer (Etudes Anatomo-Cliniques).—By I. STOIA, Docent de la Faculté du Médecine de Bucarest; Médecin chef du Laboratoire central d'Anatomie-Pathologique de l'Hôpital Brancovan; etc.; and P. STANCIULESCU, Assistant du Laboratoire central d'Anatomie-Pathologique de l'Hôpital Brancovan; etc. With a Preface by Professor CH. LENORMANT. Super royal 8vo. Pp. 322, with 147 illustrations. Paris: Masson et Cie. Fr. 55.

THIS book consists of ten short monographs on different forms of cancer in which a study has been made of the relations of the clinical symptoms to the anatomical and pathological appearances of the tumour material.

The Life and Works of Charles Barrett Lockwood (1856–1914). By ERIC C. O. JEWSBURY, M.A., B.M., B.CH. (Oxon.). The Wix Prize Essay, St. Bartholomew's Hospital, 1934. Crown 8vo. Pp. 104 + viii, with 12 illustrations 1936. London: H. K. Lewis & Co., Ltd. Cloth, 3s. 6d. net; paper covers, 2s. 6d. net.

ANYBODY familiar with the surgical side of Bart's thirty years ago will recollect what an outstanding position Lockwood occupied at that time. The admirable account of his life and work, which has been written by Eric Jewsbury, is particularly successful in that it pictures the man as we knew him with all his characteristics and eccentricities.

This little biography has been penned without fear, and it shows very well why so many people were repelled by Lockwood, if they did not frankly dislike him. But while this side of his character has been justly portrayed, it is made obvious that these characteristics were merely a cloak for a sensitive and tender nature, very apt to be misunderstood.

Lockwood was a great worker and writer, and the author has done well to supply in an appendix an apt survey of the outstanding publications for which this surgeon was responsible. In addition there is a complete bibliography, a list of authorities, the names of those to whom he has been indebted for much information. and, as though that were not sufficient, some incidental references that have a bearing on the matter in hand. It is seldom indeed that a biography so complete and so successful has been presented in such a small compass.

BOOK NOTICES

[The Editorial Committee acknowledge with thanks the receipt of the following volumes. A selection will be made from these for review, precedence being given to new books and to those having the greatest interest for our readers.]

Text-book of Pathology. By Sir ROBERT MUIR, M.A., M.D., Sc.D., LL.D., F.R.S., Professor of Pathology, University of Glasgow; Pathologist to the Western Infirmary, Glasgow. Fourth edition. Medium 8vo. Pp. 994 + viii, with 571 illustrations. 1936. London: Edward Arnold & Co. 35s. net.

Appendicitis: When and How to Operate. By W. J. STEWART MCKAY, M.B., B.Ch., B.Sc., Senior Surgeon, Lewisham Hospital, Sydney. Demy 8vo. Pp. 260 + xii, with 16 illustrations. 1936. Sydney: Angus & Robertson Ltd. 12s. 6d. net.

Die Wirbelgelenke. By Prof. Dr. MAX LANGE, Director of the Orthopædic Clinic, Munich. Second enlarged edition. Large 8vo. Pp. 138 + viii, with 94 illustrations. 1936. Stuttgart: Ferdinand Enke. RM. 10.

Techniques Chirurgicales. By A. GOSSET, Chirurgien de la Salpêtrière, Professeur de Clinique chirurgicale à la Faculté de Médicine de Paris; with the collaboration of MM. L.-G. AMIOT, IVAN BERTRAND, JEAN CHARRIER, P. FUNCK-BRENTANO, J. GARCIA-CALDERON, JEAN GOSSET, P. HAUDUROY, R. LEDOUX-LEBARD, R. LEIBOVICI, G. LŒWY, P. PETIT-DUTAILLIS, P. ROUCHÉ, R. SAUVAGE, G. SEILLÉ, R. SOUPAULT, M. THALHEIMER, and E. WALLON. Imperial 8vo. Pp. 434 + viii, with 219 illustrations. 1936. Paris: Masson et Cie. Paper covers, Fr. 105; bound, Fr. 125.

The Surgical Technic of Abdominal Operations. By JULIUS L. SPIVACK, M.D., Assistant Professor of Surgery, University of Illinois College of Medicine; Professor of Operative Surgery and Surgical Anatomy, Cook County Graduate School of Medicine; etc. 10½ × 7¼. Pp. 718 + xvi, with 362 illustrations. 1936. Chicago: S. B. Debour.

Minor Surgery. By FREDERICK CHRISTOPHER, S.B., M.D., F.A.C.S., Associate Professor of Surgery at the Northwestern University Medical School, Chicago; Chief Surgeon at the Evanston (Ill.) Hospital. With a Foreword by ALLEN B. KANAVEL, M.D., F.A.C.S., Professor of Surgery at the Northwestern University Medical School. Third edition, reset. Large 8vo. Pp. 1030, with 709 illustrations. 1936. London and Philadelphia: W. B. Saunders Co. Ltd. 42s. net.

Vorträge aus der praktischen Chirurgie. Edited by ERICH LEXER. Heft 8. Die Kurzwellenbehandlung in der Chirurgie. By Dr. ALFONS LOB, X-ray Department, University Surgical Clinic, Munich. Large royal 8vo. Pp. 68. 1936. Stuttgart: Ferdinand Enke. R.M. 3.60.

The Relief of Pain. A Handbook of Modern Analgesia. By HAROLD BALME, M.D., (Durh.), F.R.C.S. (Eng.), D.P.H. (Lond.), Formerly Professor of Surgery and Dean of the School of Medicine, Cheeloo University, China. With an introduction by Sir E. FARQUHAR BUZZARD, Bt., K.C.V.O., LL.D.(Man.), M.D. (Oxon.), F.R.C.P. Large post 8vo. Pp. 392 + xvi. 1936. London: J. & A. Churchill Ltd. 12s. 6d. net.

Recent Advances in Genito-urinary Surgery. By HAMILTON BAILEY, F.R.C.S. (Eng.), Surgeon, Royal Northern Hospital; Surgeon and Urologist, Essex County Council; and NORMAN M. MATHESON, M.B., F.R.C.S., M.R.C.P., Surgeon, Central Middlesex County Hospital. Large post 8vo. Pp. 213 + viii, with 89 illustrations. 1936. London: J. & A. Churchill Ltd. 15s. net.

Behandlung der Verletzungen und Eiterungen an Fingern und Hand. By Professor Dr. M. ZUR VERTH, Privatdozent in the University of Hamburg. Second edition. 5¾ × 8⅝. Pp. 164 + viii, with 59 illustrations. 1936. Berlin: Julius Springer. Paper covers, RM. 8.70; bound, RM. 9.60.

Diseases of the Testicle. By HAMILTON BAILEY, F.R.C.S., Surgeon, Northern Hospital; Surgeon and Urologist, Essex County Council; etc. Medium 8vo. Pp. 160 + viii, with 129 illustrations, of which 10 are coloured. 1936. London: H. K. Lewis & Co. Ltd. 12s. 6d. net.

The Patient Looks at the Hospital. By FLORENCE G. FIDLER. With a Foreword by JOAN MALLESON, M.B., B.S. Crown 8vo. Pp. 128 + xii. 1936. London: Robert Hale & Co. 2s. 6d. net.

Paget's Disease of the Nipple. By KEITH INGLIS, M.D., Ch.M. (Sydney), Professor of Pathology in the University of Sydney; Formerly Director of the Kanematsu Memorial Institute of Pathology, Sydney Hospital. Crown 4to. Pp. 233 + xii, with 237 illustrations. 1936. London: Oxford University Press. 36s. net.

Clinical Handbook for Residents, Nurses, and Students. Being the Routine Methods of St. Vincent's Hospital, Sydney. By Members of the Staff of the Hospital. Edited by VICTOR M. COPPLESON, Ch.M., F.R.C.S., F.R.A.C.S., and DOUGLAS MILLER, Ch.M., F.R.C.S., F.R.A.C.S. Cr. 8vo. Pp. 205 + x. 1936. London and Sydney: Angus & Robertson Ltd. 6s.

The Thyroid: Surgery, Syndromes, Treatment. By E. P. SLOAN, M.D. Edited by Members of the Sloan Clinic. With a Foreword by WM. SEAMAN BAINBRIDGE, M.D. 10¼ × 7¼. Pp. 475 + ix, with 99 illustrations. 1936. London: Baillière, Tindall & Cox. 45s.

Surgery for Dental Students. By PHILIP H. MITCHINER, M.D., F.R.C.S., C. E. SHATTOCK, M.D., F.R.C.S., E. G. SLESINGER, B.Sc., F.R.C.S., and CECIL P. G. WAKELEY, D.Sc., F.R.C.S. 9 × 6. Pp. 364 + ix, with 105 illustrations. 1936. London: Ballière, Tindall & Cox. 12s. 6d.